**SECTION J, ATTACHMENT J.1**

## 1.0 GENERAL PROVISIONS FOR ELECTRICAL DISTRIBUTION EQUIPMENT

### 1.1 General

#### 1.1.1 Publications

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

#### 1.1.2 American National Standards Institute (ANSI)

- ANSI C57.12.29 (2005) Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments
- AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)
- ASTM A 123/A 123M - 09 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- ASTM A 153/A 153M - 09 Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
- ASTM A 653/A 653M - 11 Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
- ASTM D 149 - 09 Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
- ASTM D 1535 – 08e1 Standard Practice for Specifying Color by the Munsell System

#### 1.1.3 Institute of Electrical and Electronics IEEE)

- IEEE C12.15 (1990) Electricity Metering Solid-State Demand Registers for Electromechanical Watthour Meters
- IEEE C12.16 (1991) Electricity Metering Solid-State Electricity Meters
- IEEE C57.12.28-2005 Standard for Pad-Mounted Equipment-Enclosure Integrity

### 1.1.4 National Electrical Manufacturer Association (NEMA)

- NEMA ICS 6 (1993; R 2006) Industrial Control and Systems Enclosures
- NEMA LI 1 (1998) Industrial Laminating Thermosetting Products
- NEMA PB 2 – 2006 Deadfront Distribution Switchboards
- NEMA PB 2.1 - 2007 Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less
- NEMA ST 20-1992 (R 1997) Dry-Type Transformers for General Applications

### 1.1.5 Underwriters Laboratories (UL)

- UL 489 (2009) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
- UL 891 (2005) Switchboards
- UL 1283 (2005) Standard for Electromagnetic Interference Filters
- UL 1449 (2006) Standard for Surge Protective Devices
- UL 1558 (1999) Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
- UL 60947-1 (2007) Low-Voltage Switchgear and Controlgear – Part 1: General Rules
- UL 60947-4-1A (2007) Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters
- UL 60947-5-2 (2007) Standard for Low-Voltage Switchgear and Controlgear – Part 5-2: Control circuit devices and switching elements - Proximity switches
- UL 60947-7-1 (2011) Standard for Low-Voltage Switchgear and Controlgear – Part 7-1: Ancillary equipment – Terminal blocks for copper conductors
- UL 60947-7-2 (2011) Standard for Low-Voltage Switchgear and Controlgear – Part 7-2: Ancillary equipment – Protective Conductor Terminal Blocks for Copper Conductors

- UL 60947-7-3 (2011) Low-Voltage Switchgear and Controlgear – Part 7-3: Ancillary equipment – Safety Requirements for Fuse Terminal Blocks

### 1.1.6 Related Requirements (Attached)

- Attachment J, Section J.2, Specification for Parallel Switchboards and Switchgear.
- Attachment J, Section J.3, Specification for Switchboards and Switchgear.
- Attachment J, Section J.4, Specification for Electrical Distribution Equipment.
- Attachment J, Section J.5, Specification for Electrical Power Control and Monitoring System.

### 1.1.7 Summary

All written material including electronic documents shall not be copyrighted or require the FAA to obtain special permission for reproduction for any purpose. This shall include, but no be limited to, Operation and Maintenance Manuals, Training Material, Shop Drawings, As-Builts, Software Code, Software Code Documentation. The FAA shall have the right to reproduce this information, as well as incorporate into their internal training programs and documents. The Contractor shall furnish the equipment specified in this specification.

## 1.2 Submittals

### 1.2.1 Compliance Review

Bidders will provide a Compliance Review of the Specifications and Addenda. The Compliance Review shall be a paragraph-by-paragraph review of the Specifications with the following information; C, D or E marked in the margin of the original Specifications and any subsequent Addenda.

1. C - Comply with no exceptions.
2. D - Comply with deviations. For each and every deviation, provide a numbered footnote with reasons for the proposed deviation and how the intent of the Specification can be satisfied.
3. E - Exception, do not comply. For each and every exception, provide a numbered footnote with reasons and possible alternatives.

**Note:** Unless a deviation or exception is specifically noted in the Compliance Review, it is assumed that the Bidder is in complete compliance with the plans and Specifications. The Bidder may propose the latest

state-of-the art components or the Bidder's standard components as a deviation. Deviations or exceptions taken in cover letters, subsidiary documents, by omission or by contradiction do not release the Bidder from being in complete compliance, unless the exception or deviation has been specifically noted in the Compliance Review and approved by the Engineer. The compliance review shall be in precise language in order to permit proper evaluation of the technical capabilities of the proposed system. All data indicated shall be used as the criteria for the selection of the proposed system. Lack of these requirements in the manufacturer's technical proposal shall be considered as a non-responsive bid and disqualify the bidder, as this data is necessary for determination of purchase, installation and operational costs associated with the Bid.

### 1.2.2 Submittal Requirements

Submit the following:

1) Detailed and dimensioned plans, section and elevations. Type and size of structural supports, metal thickness, surface finishes, bus cross sections, provisions for lifting as well as single line diagram of switch, fuse, circuit breakers, bus arrangements, metering arrangements, and electrical power monitoring system equipment arrangements.

2) Schematic wiring diagrams and a full set of equipment wiring diagrams for protective equipment relays, overcurrent relays, pilot lights, alarms, controls, and electrical power monitoring system devices. Provide narratives for all wiring diagrams.

3) Fuse sizes and types.

4) Breaker sizes and types. Circuit breakers shall be selectively coordinated to maximize power system fault tolerance and minimize incident energy levels.

5) Nameplate data.

6) Specification compliance and noncompliance submitted with Bid.

7) Milestone chart indicating the following information expressed in weeks after receipt of order.

    a. Mimic-bus diagram layout.

    b. Short-time and short-circuit ratings of switchboard assembly.

    c. Electronic and paper copies of all time current curves for overcurrent protective devices.

d. Current ratings of buses.

e. Submission of equipment shop drawings.

f. Submission of installation drawings.

g. Submission of Factory Acceptance Test Procedure.

h. Complete purchasing release of all material.

i. Completion of final assembly.

j. Submission of Site Acceptance Test Procedure.

k. Submission of O & M manuals.

l. Submission of schematic & wiring diagrams.

m. Submission of final as-built drawings .

n. Factory Acceptance Testing – Switchboards.

o. Switchboard shipping date to job site.

p. Switchboard received at site.

q. Site Acceptance Testing.

8) Catalog cuts of equipment showing as a minimum the ratings, dimensions, weight and any other technical information published for the equipment and all accessories. Submittal shall identify proposed manufacturer of the switchboard, circuit breakers and fuses, as well as the overall dimensions and weight of the shipping splits.

9) Recommended spare parts list and pricing information. The spare parts list shall include but not be limited to the items called out in the Specifications.

10) Submit a copy of the proposed preventive maintenance agreement under warranty and out of warranty based on quarterly visits, complete with preventive maintenance schedule including what maintenance is recommended by the Vendor. Indicate the nearest field service office staffed with factory trained engineers, how many engineers are at that location and how many systems are being serviced by those field engineers.

11) Submit an itemized Specification compliance stating conformance or non-conformance with each Section of this Specification. The submittal shall be in precise language in order to permit proper evaluation of the technical capabilities of the proposed system. All data indicated shall be used as the criteria for the selection of the proposed system. Lack of these requirements in the manufacturer's technical proposal shall be considered as a non-responsive bid and disqualify the bidder, as this data is necessary for determination of purchase, installation and operational costs associated with the Bid.

### 1.2.3 Shop Drawing Quality Assurance

Vendor's Drawings: Electronic copies shall be submitted to the Engineer for approval within ten business days of issuance of a Letter of Intent, prior to proceeding with any fabrication or assembly of equipment. All drawing packages and data shall be identified by the Owner project number and Specification reference. The drawing package shall contain revision boxes to describe revisions in full detail. Indication of the latest revision on each drawing shall be made by such means as a triangle-enclosed revision number. The following items as a minimum are required.

1) Outline drawings showing plan and elevation views of each piece of equipment with the size, weight, and heat dissipation of each piece of equipment, together with the size and weight of the shipping splits for each piece of equipment.

2) Base plans for the location of the equipment floor channels, anchor bolts and conduit entrance spaces, where applicable.

3) Three line wiring diagrams, showing unit wiring and markings for feeder and all control or electrical power monitoring system connections.

4) Detailed schematic diagrams and product descriptions of all systems. Include fully dimensioned component information.

5) Provide air filtration and air conditioning requirements for all operating modes.

6) Time/current characteristic curves for all circuit breakers, fuses and other circuit protection devices. Curves shall be full size logarithmic overlays.

7) Site acceptance test procedures for approval.

8) Bill of material for each drawing showing all components ratings and catalog numbers.

9) Warranty.

10) Recommended preventive maintenance procedure (outline form).

11) List of all protection settings, walk-in rate, and etc.

12) Submit electronic copy of approved shop drawings to Owner. Text shall be in Word for Windows format and drawings in AutoCAD and Adobe Acrobat.

### 1.3 Quality Assurance

Each switchboard as a complete and finished product shall receive a single integrated equipment rating by the manufacturer. The integrated equipment short circuit rating shall certify that all equipment is capable of withstanding the thermal and magnetic stress of a fault equal to the value specified on the Drawings. Such rating shall be established by actual tests by the manufacturer on similar equipment. This certification shall be permanently affixed to the switchboard.

### 1.4 Warranty

The Seller shall warranty that the equipment supplied is a proven design and can meet the requirements specified. Workmanship shall be of the best quality, free from any defects that might render the equipment unsuitable or inefficient for the purpose for which it is to be used. In the event of problems or malfunctions, the Vendor shall have qualified technicians capable of affecting all necessary repairs and restoring the system to full operation within four hours of notification. There shall be no cost to the Owner for corrective repairs during the first twelve (12) months following site acceptance by the Owner.

If at any time during the first twelve (12) months of operation as defined below, the Owner shall accumulate sufficient evidence to reasonably indicate that the equipment or any part thereof is not in accordance with the Specifications, the Owner shall so notify the Vendor in writing, and the Vendor shall repair or replace the defective components. The cost of removal, reinstallation and complete re-testing of the equipment, and any associated freight charges (via air ride truck) or service engineering charges, shall be at the Vendor's expense. The warranty for the repaired or replaced equipment shall be extended for two years from the completion of repairs or replacement.

If the equipment fails to meet the specific performance guarantees, the Vendor shall recommend to the Owner adjustments or modification. Upon approval by the Owner, the adjustments or modifications shall be made, and tests shall be rerun. The cost of these adjustments or modifications and complete re-testing shall be made at the Vendor's expense. After such adjustments or modifications, should the equipment fail

to achieve the guaranteed performance, an equitable settlement shall be made which may, without limitation, include an adjustment of the contract price.

Complete re-testing, as referred to in this Section, shall mean site acceptance testing as stipulated in testing portions of this Specification. The conditions, which apply to original testing requirements, shall also apply to the re-testing of any equipment performed under the conditions of this warranty.

Commercial operation is defined as commencing on the date on which the equipment covered by these Specifications has successfully completed final site integrated acceptance testing.

### 1.5 Shipping –FOB Jobsite

Deliver switchboard in sections of lengths that can be moved past obstructions in delivery path. No section can be greater than 72 inches wide by 72 inches deep by 94.5 inches high.

Switchboards shall be stored indoors in clean dry space with uniform temperature to prevent condensation. Protect switchboard from exposure to dirt, fumes, water, corrosive substances, and physical damage.

Delivery vehicles used to deliver switchboards shall be equipped with lift gates for offloading gear at job sites that do not have a loading dock available. Delivery drivers shall move switchboards to the rear of the delivery vehicle as needed to assist in offloading of the switchboards.

Delivery shall be coordinated with a job site point of contact at least 72 hours prior to delivery and shall only be made during normal business hours for the job site as specified by the job site point of contact. A job site point of contact shall be provided to the Vendor upon request.

### 1.6 Manufacturer Seismic Qualifications Certification

Submit certification of standard switchboards, overcurrent protective devices, accessories, and components withstand capabilities. Include the following:

1) Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2) Retain one of first two subparagraphs below to define the term "withstand" as it applies to this Project. Definition varies with type of building and occupancy and is critical to valid certification. Second definition is used for essential facilities where equipment must operate immediately after an earthquake.

3) The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

4) The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

5) Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

6) Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

## SECTION J, ATTACHMENT J.2

### 2.0 PARALLELING SWITCHBOARD SPECIFICATION

### 2.1 GENERAL REQUIREMENTS

#### 2.1.1 References
Consult the reference list in the “General Provisions” Attachment J.1.

#### 2.1.2 Related Sections
Consult the Section J, Attachment J.2, Electrical Power Monitor Control System for specifications on communication interfaces and metering requirements.

#### 2.1.3 Summary
The generator manufacturer (as defined under a separate specification) whose equipment is connected to the paralleling switchboard shall be manufactured by the current national generator contract. The controls and paralleling systems shall be of the same generator vendor or approved equal. It is the intent of this specification that the Paralleling Switchboard Manufacturer be solely responsible for the overall operation of the paralleling system. It will not be the generator manufacturer’s responsibility to ensure the overall operation of the paralleling system, but only to provide engine-generator sets.

The paralleling switchboard and circuit breakers shall be of the same manufacturer as the electrical distribution system. Alternate circuit breaker manufacturers shall not be acceptable.

#### 2.1.4 Copyright
Consult the copyright specification in the “General Provisions”, Attachment J.1.

#### 2.1.5 Submittals
Consult the information on submittals in the “General Provisions” , Attachment J.1.

#### 2.1.6 Shop Drawings Quality Assurance
Consult the information on shop drawing quality assurance in the “General Provisions”, Attachment J.1

### 2.1.7 Equipment Quality Assurance
Consult the information on equipment quality assurance in the “General Provisions”, Attachment J.1.

### 2.1.8 Warranty
Consult the information on warranties in the “General Provisions”, Attachment J.1.

### 2.1.9 Shipping –FOB Jobsite
Consult the information on shipping and deliveries in the “General Provisions”, Attachment J.1.

### 2.1.10 Manufacturer Seismic Qualification Certification
Consult the information on seismic certification in the “General Provisions”, Attachment J.1.

## 2.2 Products

### 2.2.1 Generator Paralleling Monitor and Control System

#### 2.2.1.1 Individual Generator Control and Monitoring Panel
Provide each generator with a control and monitoring panel that allows the operator to view status and control operation of respective generator. Provide panel with the following features and characteristics.

1) Generator Metering including ammeter, voltmeter, frequency meter, wattmeter, kilowatt-hour meter and power factor meter. All meters shall be1 percent accuracy class or better. For three-phase and four-wire systems, indicate line-to-line and line-to-neutral conditions on voltmeter. Provide analog devices for voltmeter and frequency meters. Provide switches or other provisions to allow reading of both generator and bus voltages and frequencies from this metering set.

2) Synchroscope and "Generator Set Synchronized" Indication. Provide lamp or LED indication of synchronization. Also provide 360-degree analog movement synchroscope.

3) Engine run-time meter, start counter, rpm meter, and battery voltage meter.

4) Engine oil temperature gage and engine coolant temperature gage.

5) Provide the following Generator Protective and Control Switches. All switches shall be oil-tight, industrial-grade.

    a. Mode Selector Switch (Run/Off/Auto):

b. "Run" mode to start and accelerate unit to rated speed and voltage, but not close paralleling circuit breaker.

c. "Off" mode to prevent generator from starting or to immediately shutdown generator if running.

d. "Auto" mode to allow generator to start on receipt of remote start signal.

e. Circuit-Breaker Trip/Close Switch: Interlocked with system control so that circuit-breaker closure is impossible unless the following occurs:

f. Mode selector switch is in "Run" position.

g. Generator set is synchronized with system bus.

h. Control/reset push button with flashing lamp to indicate generator is locked out due to fault condition.

i. Lamp test push button to simultaneously test all lamps on panel.

j. Control Panel Illumination: DC lamps to illuminate panel when lighting from surrounding environment is not available.

k. Emergency Stop Push Button: Red mushroom-head switch maintaining its position until manually reset.

l. Voltage and Frequency Raise/Lower Switches. Switches shall allow plus/minus 5 percent adjustment when generator set is operating but not paralleled.

6) Generator Protective and Control Devices: Solid-state industrial relays, integrated microprocessor-based control devices, and other accessories and devices located either in generator control and monitoring panel or in switchboard control section to provide the following features and functions:

a. Kilowatt Load Sharing Control:

i. Operates engine governors during synchronizing and provides isochronous load sharing when paralleled.

ii. Allows generator set to ramp up to kilowatt load level signaled by system master controller.

b. Load-Demand Governing Control:

    i. Causes generator set to ramp down to zero load when signaled to shut down in load-demand mode.

    ii. Causes generator set to ramp up to a proportional share of total bus load.

c. Kilovolt Ampere Rating Load Sharing Control:

    i. Operates alternator excitation system while generator set is paralleled.

    ii. Causes sharing of reactive load among all generator sets to within 1 percent of equal levels without voltage drop.

d. Sync-Check and Paralleling Monitor and Control:

    i. Monitors and verifies that generator set has reached 90 percent of nominal voltage and frequency before closing to bus.

    ii. Prevents out-of-phase paralleling if two or more generator sets reach operating conditions simultaneously, by sending "inhibit" signal to sets not designated by system as "first to close to bus."

    iii. Recognizes failure of "first-to-close" generator set and signals system paralleling to continue.

    iv. Prevents out-of-phase closure to bus due to errant manual or automatic operation of synchronizer.

e. Synchronizer Control:

    i. Adjusts engine governor to match voltage, frequency, and phase angle of paralleling bus.

    ii. Maintains generator-set voltage within 1 percent of bus voltage, and phase angle within 20 electrical degrees of paralleling bus for 0.5 seconds before circuit-breaker closing.

    iii. Provides "fail-to-synchronize time delay" adjustable from 10 to 120 seconds; with field selectivity to either initiate alarm or shut down generator set on failure condition.

f. Reverse Power Monitor and Control:

    i. Prevents sustained reverse power flow in generator set.

ii. Trips generator circuit breaker and initiates generator set shutdown when reverse power condition exceeds 10 percent of generator set kilowatt for three seconds.

g. Phase Rotation Monitor and Control:

i. Verifies generator set and paralleling bus phase rotation match prior to closing paralleling circuit breaker.

h. Electronic Alternator Overcurrent Alarm and Shutdown Control:

i. Monitors current flow at generator-set output terminals.

ii. Initiates alarm when load current on generator set is more than 110 percent of rated current for more than 60 seconds.

iii. Provides overcurrent shutdown function matched to thermal damage curve of alternator. Provide without instantaneous-trip function.

i. Electronic Alternator Short-Circuit Protection:

i. Provides shutdown when load current is more than 175 percent of rated current and combined time/current approaches thermal damage curve of alternator. Provide without instantaneous-trip function.

j. Loss of Excitation Monitor:

i. Initiates alarm when sensing loss of excitation to alternator while paralleled to system bus.

k. Generator-Set Start Contacts: Redundant system, 10 A at 32-V dc.

l. Cool-Down Time-Delay Control: Adjustable, 0 to 600 seconds.

m. Start Time-Delay Control: Adjustable, 0 to 300 seconds.

n. Paralleling Circuit-Breaker Monitor and Control:

i. Monitors circuit-breaker auxiliary contacts.

ii. Initiates fault signal if circuit breaker fails to close within adjustable time-delay period (0.5 to 15 seconds).

iii. Trips open and locks out paralleling circuit breaker upon paralleling circuit breaker failure to close, until manually reset.

7) Engine Protection and Local Annunciation:

   a. Provide annunciation and shutdown control modules for alarms indicated.

   b. Provide visual alarm status indicator and alarm horn with silence/acknowledge push button on generator control and monitoring panel.

   c. Annunciate the following conditions:

      i. Status, Light Only (Non-latching):

         1. Generator engine control switch not in auto (red).
         2. Generator engine control switch in auto (green).
         3. Emergency mode (red).
         4. Generator circuit breaker closed (red).
         5. Generator circuit breaker open (green).
         6. Engine stopped (green).
         7. Engine running (red).
         8. Engine cool-down (amber).

      ii. Pre-Alarm, Light and Horn (Non-latching):

         1. Pre-high coolant temperature (amber).
         2. Pre-low oil pressure (amber).
         3. Low coolant temperature (amber).
         4. Engine low battery (amber).
         5. Engine low fuel (amber).
         6. Generator fails to synchronize (amber).

      iii. Shutdown Alarm, Light and Horn (Latching):

         1. Engine overcrank (red).
         2. Engine overspeed (red).

3. Engine low oil pressure (red).
4. Engine high coolant temperature (red).
5. Engine low coolant level (red).
6. Engine remote emergency shutdown (red).
7. Generator circuit breaker tripped (red).
8. Generator loss of field (red).
9. Generator reverse power (red).
10. Generator undervoltage (red).
11. Generator overvoltage (red).
12. Generator underfrequency (red).
13. Generator overfrequency (red).

#### 2.2.1.2 Master Control System and Monitoring Equipment

Paralleling and monitoring equipment, components, and accessories for multiple generators shall have the following features and characteristics. In general, components and devices shall be mounted in the switchboard control section of the switchboard lineup.

##### 2.2.1.2.1 Paralleled System Metering

Paralleled System Metering shall include an ammeter, voltmeter, frequency meter, wattmeter, kilowatt-meter, power factor meter, kilovolt ampere, kilovolt ampere rating, and kilowatt demand meters. All meters shall have be 1 percent accuracy class or better to monitor total output of generator bus. For three-phase/four-wire systems, indicate line-to-line and line-to-neutral conditions on voltmeter. Display all functions on the HMI device.

##### 2.2.1.2.2 HMI Device

Paralleled System shall include a full-color HMI Device. HMI Device shall be a touchscreen with a minimum viewing area of 60 square inches. The Device shall allow the operator to monitor and control the complete system of paralleled generator sets. The screens shall include the following:

1) Main Menu: Include date, time, and system status messages with screen push buttons to access one-line diagram, system controls, load controls, alarms, bus metering, and individual generator-set data.

2) One-Line Diagram Screen: Depicting system configuration and system status by screen animation, screen colors, text messages, or pop-up indicators. Indicate the following minimum system conditions:

    a. Generator sets, buses, and paralleling circuit breakers energized/de-energized.

    b. Generator-set mode (run/off/auto).

    c. Generator-set status (normal/warning/shutdown/load-demand stop).

    d. Paralleling circuit-breaker status (open/closed/tripped).

    e. Bus conditions (energized/de-energized).

    f. Provide access to other screens.

3) AC Metering Screen which displays the following minimum meter data for the paralleling bus:

    a. Phase volts and amperes, kilowatt, kilovolt ampere, kilovolt ampere rating, power factor, frequency, kilowatt hour, and kilowatt demand.

    b. Real-time trend chart for system kilowatts and volts updated on not less than one-second intervals.

    c. A minimum of one historical trend chart for total system loads with intervals no shorter than five minutes and a minimum duration of four hours.

4) Generator-Set Control Screen: Provides control over individual generator sets from master system control panel. Includes the following minimum functions:

    a. Generator manual start/stop control (functional only when generator-set mounted control switch is in "Auto" position).

    b. Generator-set alarm reset.

    c. Manual paralleling and circuit-breaker controls.

5) Generator-Set Data Display Screen which provides the following minimum parameters:

    a. Engine speed, oil pressure and temperature, coolant temperature, and engine operating hours.

    b. Three-phase voltage and current, kilowatt, power factor, and kilowatt hour.

    c. Generator control switch position and paralleling circuit-breaker position.

d. All generator-set alarms.

6) System Control Screen which is password protected and provides the following minimum functions:

a. System Test Modes: Test with load/test without load/normal/retransfer time-delay override.

b. Test with Load: Starts and synchronizes generator sets on paralleling bus; all loads are transferred to bus.

c. Test without Load: Starts and synchronizes generator sets on paralleling bus but does not transfer loads to bus.

d. Time adjustments for retransfer time delay, transfer time delay, system time delay on stopping, and system time delay on starting.

e. Load-Demand Control Screen: Monitors total load on system bus and controls number of generator sets running so that capacity tracks load demand.

i. Load-Demand Control: On/off.

ii. Load-Demand Pickup Set Point: Adjustable from 90 to 40 percent in 5 percent increments

iii. Load-Demand Dropout Set Point: Adjustable from 20 to 70 percent in 5 percent increments.

7) Manual Load Control Screen which allows the operator to manually add or delete generator sets from paralleled system in response to system load parameters. Screen shall provide:

a. Indication of system available in kilowatts and amperes.

b. Control functions allow manual addition/removal of generator sets on system, and activation of load-shed/load-restore functions.

c. Load-Add/Load-Shed Sequence Screen: Password protected and with the following minimum functions:

i. Assigns "load-add sequence priority" to each load control relay with designation for relay operation after a set number of generator sets are online.

ii. Assigns "load-shed sequence priority" to each load control relay with designation for relay operation depending on number of generator sets online.

8) Alarm Summary and Run Report Screen shall have the following characteristics:

a. Lists most recent alarm conditions and status changes.

b. Lists a minimum of the most recent 32 alarm conditions by name and time/date; acknowledges alarm conditions with time/date.

c. For each start signal, lists start time and date, stop time and date, maximum kilowatt and ampere load on system during run time, and start and stop times of individual generator sets.

#### 2.2.1.2.3 Solid-State System Status Panel

Solid-State System Status Panel shall provide a visual alarm status indicator and alarm horn with silence/acknowledge push button. The panel shall annunciate the following conditions:

1) Status, Light Only:

   a. Running Status: Display generator set number and "green" running-status light.

   b. Load demand mode (green).

   c. Priority Load Status: Display load number and "green" on-status light.

   d. System test (green).

   e. Remote system start (red).

   f. Normal source available (green).

   g. Connected to normal (green).

   h. Generator source available (green).

   i. Connected to generator source (green).

2) Status, Light and Alarm:

   a. Load-Shed Level Status: Displays load number and red load-shed, status light.

   b. Generator Alarm Status: Displays generator number and red "Check Generator" status light.

   c. Controller malfunction (red).

   d. Check station battery (red).

   e. Bus overload (red).

f. System not in auto (red).

### 2.2.2 System Operation

#### 2.2.2.1 Loss of Normal Power

Description of System Operation, Loss of Normal Power:

1) System receives "start" signal; all generator sets start and achieve rated voltage and frequency.

2) System closes the first generator set achieving 90 percent of rated voltage to paralleling bus.

3) "Priority load add" controls prevent overloading of system.

4) Remaining generator sets switched to synchronizers that control and then allow closure of generator sets to paralleling bus. All Generators shall be on bus within 10 seconds.

5) On closure to paralleling bus, each generator set assumes its proportional share of total load.

#### 2.2.2.2 Failure to Start or Synchronize

Description of System Operation, Failure of a Generator Set to Start or Synchronize:

1) After expiration of overcrank time delay, generator set shuts down and alarm is initiated.

2) Priority controller prevents overload of system bus.

3) Manual override of priority controller at allows addition of low-priority load to bus.

4) Bus overload monitor protects bus from manual overloading.

#### 2.2.2.3 Bus Overload

Description of System Operation, Bus Overload:

1) On bus overload, load-shed control initiates load shedding.

2) If bus does not return to normal frequency within adjustable time period, additional load continues to be shed until bus returns to normal frequency.

3) Loads shed can be reconnected to bus only by manual reset at HMI.

#### 2.2.2.4 Load-Demand Mode

Description of System Operation, Load-Demand Mode:

1) With "load-demand" function activated, controller continuously monitors total bus load.
2) If bus load is below preset limits for 15 minutes, demand controller shuts down generator sets in predetermined order until minimum number of sets are operating.
3) On sensing available bus capacity diminished to set point, controller starts and closes generator sets to bus to accommodate load.

#### 2.2.2.5 Return to Normal Power

Description of System Operation , Return to Normal Power:

1) Process starts on removal of start signals from system.
2) When no load remains on paralleling bus, all generator breakers open, go through cool-down period, and shut down.
3) If start signal is received during cool-down period, one generator set is reconnected to bus, and system operation follows that of "loss of normal power."

### 2.2.3 MANUFACTURED UNITS

#### 2.2.3.1 General Requirements

Factory assembled and tested and complying with IEEE C37.20.1.

##### 2.2.3.1.1 Ratings:

Suitable for application in 3-phase, 60-Hz, solidly grounded neutral system.

##### 2.2.3.1.2 Indoor Enclosure Material

Steel.

##### 2.2.3.1.3 Access:

Fabricate enclosure with hinged, rear cover panels to allow access to rear interior of switchboard.

#### 2.2.3.1.4 Finish:

Manufacturer's standard gray finish over a rust-inhibiting primer on phosphatizing-treated metal surfaces.

#### 2.2.3.1.5 Phase-Bus, Neutral-Bus, and Ground-Bus Materials:

Buses shall extend full length of switchboard.

1) Phase and Neutral Bus: Copper, tin plated.

2) Ground Bus: Copper plated; minimum size 1/4 by 2 inches

### 2.2.3.2 Switchboard Components

Incorporate components as indicated on Drawings. Components shall have the following characteristics:

1) Instrument Transformers: Comply with IEEE C57.13.

    a. Potential Transformers: Secondary-voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.

    b. Current Transformers: Burden and accuracy class suitable for connected relays, meters, and instruments.

2) Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems, listed and labeled by UL, and with the following features:

    a. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600

    b. Switch-selectable digital display with the following features:

        i. Phase Currents, Each Phase: Plus or minus 1 percent.

        ii. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.

        iii. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.

        iv. Three-Phase Real Power: Plus or minus 2 percent.

        v. Three-Phase Reactive Power: Plus or minus 2 percent.

        vi. Power Factor: Plus or minus 2 percent.

        vii. Frequency: Plus or minus 0.5 percent.

viii. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.

ix. Accumulated energy, in megawatt hours, plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

3) Communications module suitable for remote monitoring of meter quantities and functions. Interface communication and metering requirements according to specification "Electrical Power Monitoring System" (EPMS).

4) Mounting: Display and control unit that is flush or semi-flush mounted in instrument compartment door.

5) Analog Instruments: Rectangular, 4-1/2 inches square, accurate within 1 percent; semi-flush mounting, with anti-parallax 250-degree scale and external zero adjustment; complying with ANSI C39.1.

6) Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.

7) Voltmeter Selector Switch: Rotary type with off position; provides readings of phase-to-phase and phase-to-neutral voltages.

8) Ammeters: Cover an expanded scale range of bus rating plus 10 percent.

9) Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in off position.

10) Locate meter and selector switch on circuit-breaker compartment door for indicated feeder circuits only.

11) Watt-Hour Meters: Flush or semi-flush-mounting type, 5 A, 120 V, 3 phase, 3 wire; with 3 elements, 15-minute indicating demand register, and provision for testing and adding pulse initiation.

12) Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with 15-minute interval.

    a. Operation: Counts and records a succession of pulses entering two channels.

    b. Housing: Draw-out, back-connected case arranged for semi-flush mounting.

13) Relays: Comply with IEEE C37.90, integrated digital type; with test blocks and plugs.

14) Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.

15) Control Power Supply: Control power transformer supplies 120-V control circuits through secondary disconnect devices. Include the following features:

a. Dry-type transformers, in separate compartments for units larger than 3 kVA, including primary and secondary fuses.

b. Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.

c. Secondary windings connected through relay(s) to control bus to affect an automatic transfer scheme.

d. Secondary windings connected through an internal automatic transfer switch to switchboard control power bus.

16) Control Power Fuses: Primary and secondary fuses provide current-limiting and overload protection.

17) Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:

a. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.

### 2.2.3.3 Identification

Electrical identification devices placed on equipment shall match electrical distribution switchboards and as specified below:

1) Identify units, devices, controls, and wiring.

2) Mimic Bus: Continuous mimic bus, applied to front of switchboard, arranged in one-line diagram format, using symbols and lettered designations consistent with approved mimic-bus diagram.

a. Mimic-bus segments coordinated with devices in switchboard sections to which applied, to produce a concise visual presentation of principal switchboard components and connections.

b. Medium: Painted graphics.

c. Color: Contrasting with factory-finish background.

#### 2.2.3.3.1 Nameplates:

Nameplates shall be as indicated on the drawings. Color of nameplates and information required are listed on the drawings. Deviation of the appearance is unacceptable. Labeling shall be laminated phenolic compound and engraved. Nameplates shall be attached using self-tapping stainless steel screws. The

material and methods for attaching shall last for a minimum of 25 years. Nameplates shall be clearly shown in the submittal.

Also refer to drawings for labeling associated with the equipment name. A horizontal strip across the top of the equipment will indicate equipment designation. Provide samples for review.

### 2.2.3.4 Control Battery System:

Control Battery System shall have the following characteristics:

1) System Requirements: Battery shall have number of cells and ampere-hour capacity based on an initial specific gravity of 1.210 at 25 degrees Celsius with electrolyte at normal level and minimum ambient temperature of 13 degrees Celsius. The battery should be cycled before shipment to guarantee rated capacity on installation. Arrange battery to operate ungrounded.

2) Battery: Lead-calcium type in sealed, clear plastic or glass containers, complete with electrolyte, fully charged, and arranged for shipment with electrolyte in cells. System batteries shall be suitable for service at an ambient temperature ranging from minus 18 to 25 degrees Celsius. Limit variation of current output to 0.8 percent for each degree below 25 degrees Celsius down to minus 8 degrees Celsius.

3) Rack: Two-step rack with electrical connections between battery cells and between rows of cells; include two flexible connectors with bolted-type terminals for output leads Rate battery rack, cell supports, and anchorage for seismic requirements.

4) Charger: Static-type silicon rectifier equipped with automatic regulation and provision for manual and automatic adjustment of charging rate. Unit shall automatically maintain output voltage within 0.5 percent from no load to rated charger output current, with ac input-voltage variation of plus or minus 10 percent and input-frequency variation of plus or minus 3 Hz. Other features of charger include the following:

    a. DC ammeter.

    b. DC Voltmeter: Maximum error of 5 percent at full-charge voltage; operates with toggle switch to select between battery and charger voltages.

    c. Ground Indication: Two appropriately labeled lights to indicate circuit ground, connected in series between negative and positive terminals, and with midpoint junction connected to ground by normally open push-button contact.

5) Capacity: Sufficient to supply steady load, float-charge battery between 2.20 and 2.25 V per cell and equalizing charge at 2.33 V per cell.

6) Charging-Rate Switch: Manually operated switch provides for transferring to higher charging rate. Charger operates automatically after switch operation until manually reset.

7) AC power supply is 120 V, 60 Hz, subject to plus or minus 10 percent variation in voltage and plus or minus 3-Hz variation in frequency. After loss of ac power supply for any interval, charger automatically resumes charging battery.

8) Charger regulates rate of charge to prevent damage due to overload and to prevent fuses or circuit breakers from opening.

    a. Protective Feature: Current-limiting device or circuit, which limits output current to rating of charger but does not disconnect charger from either battery or ac supply; protects charger from damage due to overload, including short circuit on output terminals.

9) Electrical Filtering: Reduces charger's audible noise to less than 26 dB.

## 2.2.3.5 METAL-CLAD, CIRCUIT-BREAKER SWITCHBOARD (1000 V AND LESS)

### 2.2.3.5.1 Description

Factory assembled and tested, and complying with IEEE C37.20.1. Switchboard shall have the following characteristics:

1) Nominal System Voltage: 480 V, 3 wire, 60 Hz.

2) Main-Bus Continuous: 4000

3) Short-Time and Short-Circuit Current: Match rating of highest-rated circuit breaker in switchboard assembly.

### 2.2.3.5.2 Switchboard Fabrication

Switchboard shall be fabricated to meet the following specifications:

1) Bus isolation barriers shall be arranged to isolate line bus from load bus at each main and tie circuit breaker.

2) Circuit-breaker compartments shall be equipped to house drawout-type circuit breakers and shall be fitted with hinged outer doors.

3) Auxiliary Compartments: Match and align with basic switchboard assembly. Include the following:

a. Bus transition sections.

b. Pull sections.

c. Hinged front panels for access to accessory and blank compartments.

d. Pull box on top of switchboard for extra room for pulling cable; with removable top, front, and side covers; and ventilation provisions adequate to maintain air temperature in pull box within same limits as switchboard.

i. Set pull box back from front to clear circuit-breaker lifting mechanism.

4) Bottom: Insulating, fire-resistive material with separate holes for cable drops into switchboard.

5) Cable Supports: Arranged to ease cabling and adequate to support cables indicated, including those for future installation.

6) Bus bars connect between vertical sections and between compartments. Cable connections are not permitted.

a. Main Phase Bus: Uniform capacity the entire length of assembly.

b. Neutral Bus: 100 percent of phase-bus ampacity, except as indicated. Equip bus with pressure-connector terminations for outgoing neutral conductors.

c. Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers.

d. Supports and Bracing for Buses: Adequate strength for indicated short-circuit currents.

e. Neutral Disconnect Link: Bolted, uninsulated, 1/4-by-2-inch copper bus, arranged to connect neutral bus to ground bus.

f. Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.

g. Bus-Bar Insulation: Individual bus bars wrapped with factory-applied, flame-retardant tape or spray-applied, flame-retardant insulation.

i. Sprayed Insulation Thickness: 3 mils, minimum.

ii. Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.

7) Circuit-Breaker Terminals for Cable Connections: Silver-plated copper bus extensions equipped with pressure connectors for conductors.

### 2.2.3.6 Circuit Breakers

#### 2.2.3.6.1 General Requirements

In general circuit breakers shall comply with IEEE C37.13. Ratings shall be as indicated for continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchboard. Circuit breakers shall have the following characteristics:

1) Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:
    a. Normal Closing Speed: Independent of both control and operator.
    b. Slow Closing Speed: Optional with operator for inspection and adjustment.
    c. Stored-Energy Mechanism: Electrically charged, with optional manual charging.
    d. Operation counter.
2) Trip Devices: Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:
    a. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
    b. Temperature Compensation: Ensures accuracy and calibration stability from minus 5 to plus 40 degrees Celsius.
    c. Field-adjustable, time-current characteristics.
    d. Current Adjustability: Dial settings and rating plugs on trip units or sensors on circuit breakers, or a combination of these methods.
        i. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."

ii. Pickup Points: Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I2t operation.

iii. Pickup Points: Five minimum, for instantaneous-trip functions.

iv. Ground-fault protection with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup. Arrange to provide protection for the following:

1. Three-wire circuit or system.

2. Four-wire circuit or system.

e. Trip units shall be labeled and have battery-powered lights or mechanical targets on trip device to indicate type of fault.

3) Auxiliary Contacts: For interlocking or remote indication of circuit-breaker position, with spare auxiliary switches and other auxiliary switches required for normal circuit-breaker operation, quantity as indicated. Each consists of two Type "a" and two Type "b" stages (contacts) wired through secondary disconnect devices to a terminal block in stationary housing.

4) Draw-out Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in connected, test, and disconnected positions. Include the following features:

a. Interlocks: Prevent movement of circuit breaker to or from connected position when it is closed.

b. Circuit-Breaker Positioning: An open circuit breaker may be racked to or from connected, test, and disconnected positions only with the associated compartment door closed, unless live parts are covered by a full dead-front shield. An open circuit breaker may be manually withdrawn to a position for removal from the structure with the door open. Status for connection devices for different positions includes the following:

i. Test Position: Primary disconnect devices disengaged, and secondary disconnect devices and ground contact engaged.

ii. Disconnected Position: Primary and secondary devices and ground contact disengaged.

5) Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.

6) Operating Handle: One for each circuit breaker capable of manual operation.

7) Electric Close Button: One for each electrically operated circuit breaker.

8) Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.

9) Key Interlocks: Arranged so keys are attached at devices indicated. Mountings and hardware are included where future installation of key-interlock devices is indicated.

10) Undervoltage Trip Devices: Instantaneous, with adjustable pickup voltage.

11) Undervoltage Trip Devices: Adjustable time-delay and pickup voltage.

12) Shunt-Trip Devices: Where indicated.

13) Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices.

#### 2.2.3.7 Accessories

Furnish tools and miscellaneous items required for circuit-breaker and switchboard tests, inspections, maintenance, and operation. Accessories shall include the following:

1) Racking handle to manually move circuit breaker between connected and disconnected positions.

2) Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchboard.

3) Relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

##### 2.2.3.7.1 Circuit-Breaker Removal Apparatus:

Apparatus shall be portable, floor-supported, roller-base, elevating carriage arranged for moving circuit breakers in and out of compartments or an overhead-circuit-breaker lifting device, track mounted at top

front of switchboard and complete with hoist and lifting yokes matching each size of draw-out circuit breaker installed.

#### 2.2.3.7.2 Spare-Fuse Cabinet:
Cabinet shall be identified and compartmented steel box or cabinet with lockable door.

#### 2.2.3.7.3 Storage for Manual
Equipment shall include a rack or holder, near the operating instructions, for a copy of maintenance manual.

### 2.2.3.8 Surge Protective Device (SPD)
The SPD units and all components shall be designed, manufactured and tested in accordance with the latest UL Standards (UL 1449 and UL 1283). Provide the SPD within the assembly as indicated. Locate suppressor on load side of the main protective device as close as possible to the phase conductors and ground bar. The main surge current per phase capacity shall be as indicated. The SPD surge current shall be equally distributed to all MOV components to ensure equal stressing and maximum performance. The unit shall include EMI/RFI noise rejection filter and continuous monitoring, including fault detection.

## 2.2.4 Execution

### 2.2.4.1 Factory Testing
GFE vendors shall perform factory tests on their GFE. The Contractor shall submit five (5) copies of factory test reports to the Contracting Officer's Technical Representative for each tested piece of equipment.

A Contractor’s representative shall be present for all factory testing. The COTR shall provide one (1) copy of factory test reports to the contractor. The Contractor shall compile a consolidated set the test reports for each GFE equipment for inclusion with submission for the contractor acceptance inspection requirements indicated in Part 3.4 of this section.

Provide as part of this submittal, provisions for five (5) individuals to attend the first two factory witness tests. In total, there shall be two (2) factory witness tests. Vendor shall pay for hotels, airfare, and meals.

### 2.2.4.2 Field Testing
Field testing shall consist of the following:

1) Visual and Mechanical Inspection:

    a. Compare equipment nameplate information with drawings and specification.

    b. Inspect physical, electrical, and mechanical condition.

    c. Check for correct anchorage, required area clearances, and correct alignment.

    d. Verify that fuse sizes and types correspond to drawings.

    e. Test all electrical and mechanical interlock systems for correct operating and sequencing.

2) Control System Testing:

    a. Where a control system is part of the GFE requirements, the Contractor shall perform electrical tests for the control system as follows:

        i. Perform insulation-resistance tests, phase-to-phase and phase-to-ground, with switch in both source positions.

        ii. Verify settings and operation of control devices.

        iii. Perform transfer tests to simulate loss of normal power; return to normal power; loss of emergency power; and all forms of single-phase conditions.

    b. Correct Operation and Timing:

        i. Verify correct operating and timing of the following functions:

        ii. Normal source voltage-sensing relays.

        iii. Time delay upon transfers.

        iv. Alternate source voltage-sensing relays.

        v. Any automatic operations.

        vi. Interlocks and limit switch function.

        vii. Time delays and re-transfer upon normal power restoration.

### 2.2.4.3 TEST RESULTS

Circuit breaker test results shall conform to the following:

1) Bolt-torque levels shall be in accordance with Table A.9 unless otherwise specified by the manufacturer.

2) Compare microhm or millivolt drop values to adjacent poles and similar breakers. Investigate deviations of more than 25 percent. Investigate any value exceeding manufacturer's recommendations.

3) Insulation resistance shall not be less than 100 megohms.

4) Trip characteristic of breakers shall fall within manufacturer's published time-current characteristic tolerance bank, including adjustment factors.

5) Ratings and settings shall comply with the results and requirements of the short circuit and circuit breaker coordination studies performed for this project.

#### 2.2.4.4 Contractor Acceptance Inspection (CAI)

Upon completion of the installation and certification from the Contractor that the installation is complete in every respect, the Contractor shall arrange to have an independent field testing agency perform a CAI on the GFE. This inspection shall include inspecting each equipment installation for proper mechanical and electrical installation, exercising the system in all possible modes of operation, checking and calibrating each system point, printing and displaying each system point, entering and deleting new points, and using any password systems. These tests shall be conducted in the presence of FAA representative, who shall conditionally accept the system installation. Any training provided by the GFE vendor shall be conducted prior to CAI. System performance testing will be performed by FAA in conjunction with CAI.

#### 2.2.4.5 Joint Acceptance Inspection (JAI )

The Contractor and the Government each will provide one or more GFE system specialist/engineers who will be available to answer questions and resolve difficulties during FAA system JAI.

#### 2.2.4.6 Test Plans

The Contractor shall submit a Contractor's Master Test Plan. This document shall define the overall test philosophy and summarize all tests to be conducted. It shall describe methods for implementing and controlling the testing programs. The Master Test Plan shall require test performance reports to document the results of all tests. All test plans shall be reviewed by the COTR before any testing can occur. Therefore, a test plan that describes the methods to be used for each system test shall be submitted at least 45 days before the scheduled test date. Include a step-by-step description of the tests, and indicate type and

location of test apparatus to be employed. Demonstrate that the operation and installation requirements specified have been met.

#### 2.2.4.7 Test Procedures

A separate test procedure shall be prepared for each test run to be conducted by the Contractor as identified in the Contractor's Master Test Plan. Test procedure shall include the detailed procedures and background information required for the conduct of a specified test run. The test procedures shall include the following:

- Title page
- Location and schedule
- References
- Personnel and responsibilities
- Equipment and computer program requirements
- Test Operating Procedures
- Detailed test descriptions
- Detailed test verification
- Recording and reduction requirements
- Data reduction and analysis procedures

#### 2.2.4.8 Test Performance

Test performance reports document the results of a test. They are used to identify and evaluate discrepancies between expect and actual test results. The test report shall contain the following:

- Identification of the specific test
- Purpose of the test
- Specific test objective

- References to applicable test plan and procedure
- Description of the test article
- List of all test equipment
- Description of the criteria used
- Summary of test results
- Detailed test results
- Test evaluation
- Certification that the test results are authentic, accurate, current, and in accordance with related requirements and test plans

### 2.2.5 TRAINING

The Contractor has no responsibility for personnel training for government furnished equipment.

### 2.2.6 SUPPORT AND SUPPLIES

Contractor's request for information (RFI) as it relates to installation and wiring of GFE shall be submitted to the COTR for resolution.

# SECTION J, ATTACHMENT J.3

## 3.0 SWITCHBOARD AND SWITCHGEAR SPECIFICATION

### 3.1 General

### 3.1.1 References

#### 3.1.1.1 Publications

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

- AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
    - ANSI C57.12.29(2005) Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments
- AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)
    - ASTM A 123/A 123M - 09 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
    - ASTM A 153/A 153M - 09 Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
    - ASTM A 653/A 653M - 11 Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
    - ASTM D 149 - 09 Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
    - ASTM D 1535 – 08e1 Standard Practice for Specifying Color by the Munsell System
- INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)
    - IEEE C12.15(1990) Electricity Metering Solid-State Demand Registers for Electromechanical Watthour Meters
    - IEEE C12.16(1991) Electricity Metering Solid-State Electricity Meters

- IEEE C57.12.28-2005 Standard for Pad-Mounted Equipment-Enclosure Integrity

- NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)
  - NEMA ICS 6 (1993; R 2006) Industrial Control and Systems Enclosures
  - NEMA LI 1 (1998) Industrial Laminating Thermosetting Products
  - NEMA PB 2 - 2006 Deadfront Distribution Switchboards
  - NEMA PB 2.1 - 2007 Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less
  - NEMA ST 20-1992 (R 1997) Dry-Type Transformers for General Applications
- UNDERWRITERS LABORATORIES (UL)
  - UL 489 (2009) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
  - UL 891 (2005) Switchboards
  - UL 1283 (2005) Standard for Electromagnetic Interference Filters
  - UL 1449 (2006) Standard for Surge Protective Devices
  - UL 1558 (1999) Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
  - UL 60947-1 (2007) Low-Voltage Switchgear and Controlgear – Part 1: General Rules
  - UL 60947-4-1A (2007) Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters
  - UL 60947-5-2 (2007) Standard for Low-Voltage Switchgear and Controlgear – Part 5-2: Control circuit devices and switching elements - Proximity switches
  - UL 60947-7-1 (2011) Standard for Low-Voltage Switchgear and Controlgear – Part 7-1: Ancillary equipment – Terminal blocks for copper conductors
  - UL 60947-7-2 (2011) Standard for Low-Voltage Switchgear and Controlgear – Part 7-2: Ancillary equipment – Protective Conductor Terminal Blocks for Copper Conductors

- UL 60947-7-3 (2011) Low-Voltage Switchgear and Controlgear – Part 7-3: Ancillary equipment – Safety Requirements for Fuse Terminal Blocks

#### 3.1.1.2 Related Requirements

- Specification listed in Section J, Attachment J.5, Electrical Power Monitoring and Control System
- Specification listed in Section J, Attachment J.1, General Provisions

#### 3.1.1.3 Summary

All written material including electronic documents shall not be copyrighted or require the FAA to obtain special permission for reproduction for any purpose. This shall include, but no be limited to, Operation and Maintenance Manuals, Training Material, Shop Drawings, As-Builts, Software Code, Software Code Documentation. The FAA shall have the right to reproduce this information, as well as incorporate into their internal training programs and documents. The Contractor shall furnish the equipment specified in this specification.

### 3.1.2 Submittals

See Section J, Attachment J.1, General Provisions for Electrical Distribution Equipment.

### 3.1.3 Shop Drawings Quality Assurance

See Section J, Attachment J.1, General Provisions for Electrical Distribution Equipment.

### 3.1.4 Quality Assurance

See Section J, Attachment J.1, General Provisions for Electrical Distribution Equipment.

### 3.1.5 Warranty

See Section J, Attachment J.1, General Provisions for Electrical Distribution Equipment.

### 3.1.6 Shipping-FOB Jobsite

See Section J, Attachment J.1, General Provisions for Electrical Distribution Equipment.

### 3.1.7 Manufacturer Seismic Qualification Certification:
See Section J, Attachment J.1, General Provisions for Electrical Distribution Equipment.

## 3.2 Products

### 3.2.1 Product Coordination
Products and materials not considered to be switchboards or switchgear and related accessories are specified in "Interior Distribution System" specification.

### 3.2.2 Switchboard and Switchgear
Switchboards and switchgear shall be in accordance with NEMA PB 2 and UL 891.

#### 3.2.2.1 Ratings
The voltage rating of the switchboard or switchgear shall be as indicated. The continuous current rating of the main bus shall be as indicated. The short-circuit current rating shall be as indicated. The switchboard or switchgear shall be UL listed and labeled for its intended use and as service entrance equipment.

#### 3.2.2.2 Construction
Switchboard or switchgear shall consist of vertical sections bolted together to form a rigid assembly and shall be front and rear aligned . All circuit breakers shall be front accessible. Front and rear aligned switchboards or switchgear shall have rear accessible load connections. Compartmentalized switchboards or switchgear shall have vertical insulating barriers between the front device section, the main bus section, and the cable compartment. Where indicated, "space for future" or "space" shall mean to include bus, device supports, and connections. Provide insulating barriers in accordance with NEMA LI 1, Type GPO-3, 6.35 mm 0.25 inch minimum thickness. Apply moisture resistant coating to all rough-cut edges of barriers. Switchboard or switchgear shall be completely factory engineered and assembled, including protective devices and equipment indicated with necessary interconnections, instrumentation, electrical power monitoring system wiring, and electrical power control system wiring. Circuit Breakers shall be rear connected, individually mounted, drawout construction where shown on the single line diagrams.

#### 3.2.2.3 Enclosure
The switchboard or switchgear enclosure shall be listed to Underwriters Laboratories (UL) 891. Enclosure shall be bolted together with removable bolt-on side and hinged rear covers. Front and rear doors shall be provided with pad lockable vault handles with a three point catch. Bases, frames and channels of

enclosure shall be corrosion resistant and shall be fabricated of galvanized steel. Base shall include any part of enclosure that is within 75 mm 3 inches of concrete pad. Galvanized steel shall be ASTM A 123/A 123M, ASTM A 653/A 653M G90 coating, and ASTM A 153/A 153M, as applicable. Galvanize after fabrication where practicable. Paint enclosure, including bases, ASTM D 1535 light gray No. 61 or No. 49. Paint coating system shall comply with NEMA C57.12.28 for galvanized steel.

#### 3.2.2.4 Bus Bars

Bus bars shall be copper with silver-plated contact surfaces. Plating shall be a minimum of .005mm (0.0002 inch) thick. Make bus connections and joints with hardened steel bolts. The through-bus shall be rated at the full ampacity of the main throughout the switchboard or switchgear. Provide minimum 6.35 mm by 50.8 mm (one-quarter by 2 inch) copper ground bus secured to each vertical section along the entire length of the switchboard or switchgear. The neutral bus shall be rated 100 percent of the main bus continuous current rating or 200 as indicated. Phase busbars shall be insulated with an epoxy finish power coating providing a minimum breakdown voltage of 16,000 volts per ASTM D 149.

#### 3.2.2.5 Main Section

The main section shall consist of an individually mounted drawout insulated-case circuit breaker or otherwise indicated.

#### 3.2.2.6 Distribution Sections

The distribution section shall consist of drawout insulated case circuit breakers or otherwise indicated.

#### 3.2.2.7 Auxiliary Sections

Auxiliary sections shall consist of indicated instruments, metering equipment, control equipment, electrical power monitoring system equipment, electrical power control system equipment, transformer, and current transformer compartments as indicated.

#### 3.2.2.8 Handles

Handles for individually mounted devices shall be of the same design and method of external operation. Label handles prominently to indicate device ampere rating, color coded for device type. Identify ON-OFF indication by handle position and by prominent marking.

### 3.2.3 Protective Device

Provide main and branch protective devices as indicated. All circuit breakers shall be capable of being equipped with auxiliary contacts for connection to EPMS monitoring system. Form-C contacts, one normally open and one normally closed, for remote monitoring of system operation. All circuit breakers shall be capable of being equipped with alarm switches (trip indication) for connection to EPMS monitoring system. This is required for the timing considerations of the monitoring systems (1 millisecond). Required circuit breaker accessories shall be specified during the design process.

#### 3.2.3.1 Power Circuit Breaker

IEEE C37.13. Low-voltage power circuit breaker with a short-circuit current rating as indicated. Series rated circuit breakers are unacceptable. Breaker frame size shall be as indicated. Equip electrically operated breakers (where shown on the drawings) with motor-charged, stored-energy closing mechanism to permit rapid and safe closing of the breaker against fault currents within the short time rating of the breaker, independent of the operator's strength or effort in closing the handle.

#### 3.2.3.2 Molded-Case Circuit Breaker

UL 489. UL listed and labeled, 100 percent rated, stationary, manually operated, low voltage molded-case circuit breaker, with a short-circuit current rating of as indicated. Breaker frame size shall be as indicated. Series rated circuit breakers are unacceptable.

#### 3.2.3.3 Draw-out Breakers

Equip draw-out breakers with disconnecting contacts, wheels, and interlocks for draw-out application. The main, auxiliary, and control disconnecting contacts shall be silver-plated, multi-finger, positive pressure, self-aligning type. Each drawout breaker shall be provided with four-position operation.

Each position shall be clearly identified by an indicator on the circuit breaker front panel.

1) Connected Position: Primary and secondary contacts are fully engaged. Breaker must be tripped before racking into or out of position.

2) Test Position: Primary contacts are disconnected but secondary contacts remain fully engaged. Position shall allow complete test and operation of the breaker without energizing the primary circuit.

3) Disconnected Position: Primary and secondary contacts are disconnected.

4) Withdrawn (Removed) Position: Places breaker completely out of compartment, ready for removal. Removal of the breaker shall actuate assembly that isolates the primary stabs.

#### 3.2.3.4 Key Locks

Provision for up to two key locks shall be furnished allowing locking in the disconnected positions.

#### 3.2.3.5 Padlocks

Padlocking shall be furnished when circuit breaker is in the disconnected position, positively preventing unauthorized closing of the circuit breaker contacts.

#### 3.2.3.6 Electronic Trip Units

Equip main and distribution breakers as indicated with a solid-state tripping system consisting of three current sensors and a microprocessor-based trip unit that will provide true rms sensing adjustable time-current circuit protection. The ampere rating of the current sensors shall be as indicated. The trip unit ampere rating shall be as indicated. Ground fault protection shall be as indicated. The electronic trip units shall have the following features as indicated:

1) Indicated Breakers shall have long delay pick-up and time settings, and LED indication of cause of circuit breaker trip.

2) Main breakers shall have short delay pick-up and time settings and, instantaneous settings and ground fault settings as indicated.

3) Distribution breakers shall have short delay pick-up and time settings, instantaneous settings, and ground fault settings as indicated.

4) Breakers shall have a digital display for phase and ground current.

5) Breakers shall have a digital display for watts, vars, VA, kWh, kvarh, and kVAh.

6) Breakers shall have a digital display for phase voltage, and percent THD voltage and current.

7) Breakers shall have provisions for communication via a network twisted pair cable for remote monitoring and control.

8) All trip units shall be removable to allow for field upgrade.

#### 3.2.3.7 Electronic Trip Unit Central Monitor

Provide a microprocessor-based device designed to monitor and display parameters of the circuit breaker electronic trip units. The central monitor shall have the following features:

1) Alphanumeric display.
2) Indication of circuit breaker status; tripped, open, closed.
3) Cause of circuit breaker trip.
4) Phase, neutral, and ground current for each breaker.
5) Energy parameters for each breaker.
6) Provisions for communicating directly to a remote computer.

### 3.2.4 Instruments

ANSI C39.1 for electrical indicating switchboard or switchgear instruments, with 2 percent accuracy. The ac ammeters and voltmeters shall be a minimum of 50.8 mm square (2 inches square), with 4.36 rad 250-degree scale. Provide single phase indicating instruments with flush-mounted transfer switches for reading three phases.

#### 3.2.4.1 AC Ammeters

Transformer rated, 5-ampere input, 0 to Rated-ampere scale range, 60 hertz.

#### 3.2.4.2 AC Voltmeters

Self-contained.

#### 3.2.4.3 Instrument Control Switches

Provide rotary cam-operated type with positive means of indicating contact positions. Switches shall have silver-to-silver contacts enclosed in a protective cover which can be removed to inspect the contacts.

#### 3.2.4.4 Digital Meters

IEEE C37.90.1 for surge withstand. Provide true rms, plus/minus one percent accuracy, programmable, microprocessor-based meter enclosed in sealed cases with a simultaneous three line, twelve value LED

display. Meters shall have 16 mm (.56 inch), minimum, LEDs. Watt-hour meter shall have 16 mm (.56 inch), minimum, LEDs. The meters shall accept input from standard 5A secondary instrument transformers and direct voltage monitoring range to 600 volts, phase to phase. Programming shall be via a front panel display and a communication interface with a computer. Password secured programming shall be stored in non-volatile EEPROM memory. Digital communications shall be via TCP/IP over an Ethernet based network. The meter shall calculate and store average max/min demand values for all readings based on a user selectable sliding window averaging period. The meter shall have programmable hi/low set limits with two Form C dry contact relays when exceeding alarm conditions. Meter shall provide Total Harmonic Distortion (THD) measurement to the thirty-first order. Historical trend logging capability shall include ability to store up to 100,000 data points with intervals of 1 second to 180 minutes. The unit shall also store and time stamp up to 100 programmable triggered conditions. Event waveform recording shall be triggered by the rms of 2 cycles of voltage or current exceeding programmable set points. Waveforms shall be stored for all 6 channels of voltage and current for a minimum of 10 cycles prior to the event and 50 cycles past the event.

#### 3.2.4.4.1 Multi-Function Meter

Meter shall simultaneously display a selected phase to neutral voltage, phase to phase voltage, percent phase to neutral voltage THD, percent phase to phase voltage THD; a selected phase current, neutral current, percent phase current THD, percent neutral current; selected total PF, kW, KVA, kVAR, FREQ, kVAh, kWh. Detected alarm conditions include over/under current, over/under voltage, over/under KVA, over/under frequency, over/under selected PF/kVAR, voltage phase reversal, voltage imbalance, reverse power, over percent THD. The meter shall have a Form C KYZ pulse output relay.

#### 3.2.4.4.2 Power Meter

Meter shall simultaneously display Watts, VARs, and selected KVA/PF. Detected alarm conditions include over/under KVA, over/under PF, over/under VARs, over/under reverse power.

#### 3.2.4.4.3 Voltmeter

Meter shall be selectable between simultaneous display of the three phases of phase to neutral voltages and simultaneous display of the three phases of the phase to phase voltages. Detected alarm conditions include over/under voltage, over/under voltage imbalance, over percent THD.

#### 3.2.4.4.4 Ammeter

Meter shall simultaneously display phase A, B, and C currents. Detected alarm conditions include over/under current, over percent THD.

#### 3.2.4.4.5 Digital Watthour Meter

Meter shall have a single selectable display for watts, total kilowatt hours (kWh) and watt demand (Wd). The meter shall have a Form C KYZ pulse output relay.

#### 3.2.4.4.6 Meter fusing

Provide a fuse block mounted in the metering compartment containing one fuse per phase to protect the voltage input and to allow removal of power to the digital meter. Size fuses as recommended by the meter manufacturer.

### 3.2.4.5 Electronic Watt-hour Meter

Provide a switchboard or switchgear style electronic programmable watt-hour meter, semi-draw-out, semi-flush mounted, as indicated. Meter shall either be programmed at the factory or shall be programmed in the field. When field programming is performed, turn field programming device over to the Contracting Officer at completion of project. Meter shall be coordinated to system requirements and conform to IEEE C12.16.

1) Design: Provide meter designed for use on a 3-phase, 3 or 4-wire, 208Y/120 and 480Y/277 volt system with 3 current transformers. Include necessary KYZ pulse initiation hardware for Electrical Power Monitoring System (EPMS).

2) Coordination: Provide meter coordinated with ratios of current transformers and transformer secondary voltage.

3) Class: 20.

4) Form: 9S

5) Accuracy: plus or minus 1.0 percent.

6) Finish: Class II.

7) Kilowatt-hour Register: 5 digit electronic programmable type.

8) Demand Register:

    a. Provide solid state IEEE C12.15.

    b. Meter reading multiplier: Multipliers shall not be acceptable.

    c. Demand interval length: shall be programmed for 15-, 30-, or 60 minutes, all selectable, with rolling demand up to six subintervals per interval.

9) Meter fusing: Provide a fuse block mounted in the metering compartment containing one fuse per phase to protect the voltage input to the watt-hour meter. Size fuses as recommended by the meter manufacturer.

### 3.2.5 Current Transformers

Current transformers shall comply with IEEE C57.13. Transformers shall be single ratio, 60 hertz, to 5-ampere ratio, rating factor, with a metering accuracy class of 0.3 through.

### 3.2.6 SPD and SPD Disconnecting Means

The SPD units and all components shall be designed, manufactured and tested in accordance with the latest UL Standard (UL 1449 and UL 1283). Provide surge protection device (SPD) within the assembly as indicated. Locate suppressor or SPD disconnecting means on load side of the main protective device as close as possible to the phase conductors and ground bar. The main surge current per phase capacity shall be as indicated. The SPD surge current shall be equally distributed to all MOV components to ensure equal stressing and maximum performance. The unit shall include EMI/RFI noise rejection filter and continuous monitoring, including fault detection.

### 3.2.7 Heaters

Provide 120-volt heaters in each switchboard or switchgear section. Heaters shall be of sufficient capacity to control moisture condensation in the section, shall be 250 watts minimum, and shall be controlled by a thermostat located in the section. Thermostat shall be industrial type, high limit, to maintain sections within the range of 15 to 32 degrees Celsius 60 to 90 degrees Fahrenheit. Supply voltage for the heaters shall be obtained from a control power transformer within the switchboard or switchgear. If heater voltage is different than switchboard or switchgear voltage, provide transformer rated to carry 125 percent of heater full load rating. Transformer shall have 220 degrees Celsius insulation system with a temperature rise not exceeding 115 degrees Celsius and shall conform to NEMA ST 20.

### 3.2.8 Terminal Boards

Provide with engraved plastic terminal strips and screw type terminals for external wiring between components and for internal wiring between removable assemblies. Terminal boards associated with current transformers shall be short-circuiting type. Terminate conductors for current transformers with ring-tongue lugs. Terminal board identification shall be identical in similar units. External wiring shall be color coded consistently for similar terminal boards.

All connections to the EPMS system shall be through the terminal boards. Each terminal board shall be accessible and viewable from the front of the equipment. Shop drawings shall indicate each wires landing position and color. Each wire shall be individually labeled for field connections.

### 3.2.9 Wire Marking

Mark control and metering conductors at each end. Provide factory-installed, white, plastic tubing, heat stamped with black block type letters on factory-installed wiring. On field-installed wiring, provide white, preprinted, polyvinyl chloride (PVC) sleeves, heat stamped with black block type letters. Each sleeve shall contain a single letter or number, shall be elliptically shaped to securely grip the wire, and shall be keyed in such a manner to ensure alignment with adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Each wire marker shall indicate the device or equipment, including specific terminal number to which the remote end of the wire is attached.

### 3.2.10 Nameplates

Nameplates shall be as indicated on the drawings. Color of nameplates and information required are listed on the drawings. Deviation of the appearance is unacceptable. Labeling shall be laminated phenolic compound and engraved. Nameplates shall be attached using self-tapping stainless steel screws. Alternate materials and methods is welcomed, however the it must be clear that material and methods for attaching shall last 25 years. Nameplates shall be clearly shown in the submittal. Also refer to drawings for labeling associated with the equipment name. A horizontal strip across the top of the equipment will indicate equipment designation. Provide samples for review.

### 3.2.11 Mimic Bus

A continuous mimic bus arranged in a single-line diagram format, using symbols and letter designations consistent with approved mimic-bus diagram shall be mounted on the front of the enclosure indicating the bus orientation and power flow. Mimic-bus segments coordinated with devices in switchboard or switchgear sections to which applied, to produce a concise visual presentation of principal switchboard or

switchgear components and connections. Mimic bus material and mounting methods shall be as provided under NAMEPLATES. Mimic bus details shall be clearly shown in the submittal.

Provide samples for review.

### 3.2.12 Warning Signs

Distinct with letter color contrasting with background.

## 3.3 SOURCE QUALITY CONTROL

### 3.3.1 Equipment Test Schedule

The Government reserves the right to witness tests. Provide equipment test schedules for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer thirty (30) calendar days before scheduled test date. Notify Contracting Officer fifteen (15) calendar days in advance of changes to scheduled date.

Provide as part of this submittal, provisions for five (5) individuals to attend the first two (2) factory witness tests for each of the three (3) types of facilities. In total, there shall be fifteen (15) factory witness tests. Vendor shall pay for hotels, airfare, and meals.

### 3.3.2 Test Instrument Calibration

The manufacturer shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy. The accuracy shall be directly traceable to the National Institute of Standards and Technology. Instrument calibration frequency schedule shall not exceed 12 months for both test floor instruments and leased specialty equipment. Dated calibration labels shall be visible on all test equipment. Calibrating standard shall be of higher accuracy than that of the instrument tested.

Manufacture shall keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

1) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

2) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

### 3.3.3 Switchboard or Switchgear Design Tests

Tests shall be in accordance with IEEE C37.20.1 and UL 891. Furnish documentation showing the results of design tests on a product of the same series and rating as provided by this specification. The following tests shall be performed:

1) Short-circuit current test.

2) Enclosure tests.

3) Dielectric test.

### 3.3.4 Switchboard or Switchgear Production Tests

Tests shall be in accordance with NEMA PB 2 and UL 891. Furnish reports which include results of production tests performed on the actual equipment for this project. These tests include:

1) 60-hertz dielectric tests.

2) Mechanical operation tests.

3) Electrical operation and control wiring tests.

4) Ground fault sensing equipment test.

## 3.4 Kirk Key Interlocks

The switchboard or switchgear manufacturer shall provide all key interlocks on circuit breakers as indicated on the drawings. Interlocks shall be part of the switchboard or switchgear structure breaker compartment.

## 3.5 Accessory Components and Features

The manufacture shall furnish the following:

1) Accessory set including tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

2) Portable test set to test functions of solid-state trip devices without removal from switchboard or switchgear. Include relay and meter test plugs suitable for testing switchboard or switchgear meters and switchboard or switchgear class relays.

3) One portable, floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.

4) Overhead circuit-breaker lifting device, mounted at top front of switchboard or switchgear, with hoist and lifting yokes matching each drawout circuit breaker.

5) Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

6) Fungus Proofing: Permanent fungicidal treatment for switchboard or switchgear interior, including instruments and instrument transformers.

### 3.6 Execution (By Others)

# SECTION J, ATTACHMENT J.4

## 4.0 PANELBOARDS, TRANSFORMERS, DISCONNECTS AND FIXED MOUNT SWITCHGEAR SPECIFICATION

### 4.1 GENERAL

This Section includes lighting and power panelboards, switches, transformers, motor control centers and associated auxiliary equipment rated 600 V or less.

### 4.1.1 Related Requirements

- Specification for Electrical Power Monitoring and Control System (Attachment J.5)
- General Provisions (Attachment J.1)

### 4.1.2 REFERENCES

The publications listed below form a part of this specification to the extent applicable.

- National Electrical Manufacturers Association (NEMA)
    - NEMA ICS 2(2000) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 Volts
    - NEMA ICS 3(1993; R 2000) Industrial Control and System Factory Built Assemblies
    - NEMA KS 1.(2001) Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
    - NEMA ST 20 (1992; R 1997) Dry-Type Transformers for General Applications
    - NEMA TP 1 (2002) Guide for Determining Energy Efficiency for Distribution Transformers
    - NEMA AB1 Molded Case Circuit Breakers and Molded Case Switches
    - NEMA PB1 Panelboards
    - NEMA PB1.1 General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less

- NFPA 70 (2011) National Electrical Code
- UNDERWRITERS LABORATORIES (UL)
    - UL 1561(1999; R 2001) Dry-Type General Purpose and Power Transformers
    - UL 489 (2002; R 2002, Bul. 2003) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit- Breaker Enclosures
    - UL 50 (1995; R 1999, Bul. 2001) Enclosures for Electrical Equipment
    - UL 508 (1999; R 2002, Bul. 2003) Industrial Control Equipment
    - UL 67 (1993; R 2002) Panelboards
    - UL 845 (1995; R 2002, Bul. 2003) Motor Control Centers
    - UL 869A (1998; Bul. 2002) Reference Standard for Service Equipment
    - UL 943 (2003) Ground Fault Circuit Interrupters
    - UL 1699 (2003) Arc-Fault Circuit-Interrupters
    - UL 486A Wire Connectors and Soldering Lugs for Use with Copper Conductors
- FAA SPECIFICATIONS AND STANDARDS
    - FAA ORDER 6950.2 Electrical Power Policy Implementation at National Airspace System Facilities
    - FAA-C-STD-1217 Electrical Work, Interior
    - FAA Order 6950.27 Short Circuit Analysis and Protective Device Coordination Study
- FEDERAL STANDARDS (FS)
    - FS WC-375 Circuit Breakers, Molded Case, Branch Circuit and Service
    - FS WP-115 Panel, Power Distribution
- International Electrical Testing Association (NETA)

- 29 CFR 1910.7 Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL)

### 4.1.3 DEFINITIONS

Overcurrent Protective Device (OCPD): A device operative on excessive current that causes and maintains the interruption of power in the circuit it protects.

## 4.2 SUBMITTALS

The following shall be submitted in accordance with general provisions including the following:

1) Shop Drawings: Including dimensioned plans, sections, elevations, supports, and seismic bracing. Show tabulations of installed devices, major features, and voltage rating. Include enclosure type with details for types other than NEMA Type 1; bus configuration when applicable, current ratings; short-circuit current rating, features, characteristics, ratings, and factory settings of individual protective devices and auxiliary components.

2) Wiring Diagrams

3) Detailed schematic diagram including control wiring and differentiating between manufacturer-installed and field-installed wiring.

4) Panel Schedules.

5) Electrical power monitoring system equipment layout. Schematic wiring diagrams including lights, alarms, controls, and electrical power monitoring system devices.

6) Fuse sizes and types.

7) Breaker sizes and types.

8) Circuit breakers shall be selectively coordinated to ensure continuity of service, maximize power system fault tolerance and minimize incident energy levels. This will utilize current short circuit calculated value.

9) Nameplate data.

10) Specification compliance and noncompliance submitted with bid.

11) Catalog cuts of equipment showing as a minimum the ratings, dimensions, weight and any other technical information published for the equipment and all accessories. Submittal shall identify

proposed manufacturer of the switchboard, circuit breakers and fuses, as well as the overall dimensions and weight of the shipping splits.

12) Recommended spare parts list and pricing information. The spare parts list shall include but not be limited to the items called out in the Specifications.

13) Electronic copy of approved shop drawings. Text shall be in Word for Windows format and drawings in CAD and Adobe Acrobat.

### 4.3 Quality Assurance

Components and installation shall comply with NFPA 70, NEMA PB1 and UL 50. Overcurrent protective devices (OCPD) shall be provided in accordance with NEMA AB1 and UL 489.

Listed and Labeled: Provide products specified in this Section that are listed and labeled. The terms "listed" and "labeled" shall be defined as they are in NFPA 70 Article 100. Listing and labeling agency qualifications as defined in 29 CFR 1910.7.

Each panelboard as a complete and finished product shall receive a single integrated equipment rating by the manufacturer. The integrated equipment short circuit rating shall certify that all equipment is capable of withstanding the thermal and magnetic stress of a fault equal to the value specified on the Drawings. Such rating shall be established by actual tests by the manufacturer on similar equipment. This certification shall be permanently affixed to the provided gear.

### 4.4 Extra Materials

1) Keys: Furnish two spares of each type for panelboard cabinet locks.

2) Touch-up Paint for Panelboards: One 1/2-pint container.

### 4.5 Panelboards

#### 4.5.1 Panelboard Fabrication

Panelboards shall be circuit breaker equipped, dead-front type, and shall conform to FS WP-115, type I, class 1. All panelboards shall be of the same manufacturer with no substitutions allowed.

#### 4.5.1.1 Enclosures

Enclosures shall be UL 50, galvanized steel, flush- or surface-mounted cabinets as indicated. Provide cabinets with a factory applied painted finish. Panelboards shall be listed and labeled in accordance with UL 67, and shall conform to the latest requirements of NFPA 70 and NEMA PB1, type 1, class 1, unless otherwise indicated to meet environmental conditions at installed locations.

#### 4.5.1.2 Directory Frame

Directory Frame shall be metal with plastic cover, mounted inside each panelboard door.

#### 4.5.1.3 Bus

Bus shall be hard drawn copper of 98 percent conductivity to meet UL 67 temperature rise limits, and have a current density of 1000 amperes per square inch. Bus bars shall be sequenced-phased, and rigidly supported by high impact resistant, insulating bus supporting assemblies to prevent vibration or short circuits. Solder-less terminations shall be suitable for copper, UL-listed wire or cable and shall be tested and listed in conjunction with appropriate UL standards.

#### 4.5.1.4 Support Bus Bars

Support bus bars on bases independent of circuit breakers. Main buses and back pans shall be designed so that breakers may be changed without machining, drilling, or tapping. Provide isolated neutral bus in each panel for connection of circuit neutral conductors. Provide separate ground bus identified as equipment grounding bus per UL 67 for connecting grounding conductors; bond to steel cabinet.

#### 4.5.1.5 UL Listing

UL 67 and UL 50 having a short-circuit current rating suitable for use in distribution system that they are being utilized in. Panelboards for use as service disconnecting means shall additionally conform to UL 869A. Panelboards shall be circuit breaker-equipped. Design shall be such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL. "Specific breaker placement" is required in panelboards to match the breaker placement indicated in the panelboard schedule on the drawings. Use of "Subfeed Breakers" is not acceptable unless specifically indicated otherwise. Main breaker shall be "separately" mounted "above" or "below" branch breakers. Where "space only" is indicated, make provisions for future installation of breakers. Panelboard locks shall be keyed the same for single facility provided order unless otherwise directed.

#### 4.5.1.6 Directories

Directories shall indicate load served by each circuit in panelboard. Directories shall also indicate source of service to panelboard (e.g., Panel PA served from Panel MDP). Type directories and mount in holder behind transparent protective covering. Panelboards shall be listed and labeled for their intended use.

#### 4.5.1.7 Bus Bars

Phase Bus Bars shall be silver plated copper or tin plated copper.

Neutral Bus Bars shall be copper or plated copper, and insulated from panelboard. The neutral bar shall be fully rated and capable of being located in either corner of the enclosure at the line end to facilitate conductor termination. Neutral bus bars for 208Y/120V Critical Panels and electronic load panels shall have 200 percent ampacity rating of phase bus.

Main, Neutral Lugs, Ground and Neutral Buses shall be provided with mechanical connectors unless otherwise specified or required to accept specified wiring. Connectors provided by this contract shall accept wire(s) size indicated on the drawings. It is the responsibility of the equipment provider to ensure compatibility of terminations with the wire size specified in the drawings.

Equipment ground bus shall be copper, fully rated, and adequate for feeder and branch-circuit equipment ground conductors with 25 percent additional space for future conditions. Lugs shall be sized to accommodate grounding conductors shown on plans. The ground bus shall be securely bonded to the cabinet and shall be separate from the neutral bus. The number of terminations shall be equal to the number of poles in the panelboard. The ground bus bar shall be structurally integral to the panelboards, or attached to the panelboard with a bolt, nut, and lockwasher. If ground bus bar is mounted to enclosure with screw threads only, (i.e., tapped blind hole), a separate bolted ground lug shall be installed on the panelboard and bonded to the ground bus bar. Bond conductor shall have same current carrying capacity as the largest equipment grounding conductor terminated to the ground bus bar.

#### 4.5.1.8 Short Circuit Rating

Short Circuit Rating: Panelboards shall be fully rated in AIC. Minimum 10,000 AIC at 240 VAC and 14,000 AIC at 480 VAC. Consultation of SC study and or drawings is required to make this determination.

#### 4.5.1.9 Future Devices

Equip with mounting brackets, bus connections, and necessary appurtenances, for the overcurrent protective device ampere ratings indicated for future installation of devices. 25 percent spare bus space is required for submitted gear.

#### 4.5.1.10 Special Features

Included Panelboard Special Features:

1) Hinged Front Door in Door Construction: Entire front trim hinged to box with standard door within hinged trim cover (one piece front with two doors). The smaller door, when open, provides access to device handles and rating labels and shall be lockable. The larger door, when open, provides access to conductors and wiring terminals and shall be lockable. Door hinges shall be continuous piano hinges which are welded to the door(s) and bolt on front. All door hinges shall be concealed.

2) Skirt for Surface-Mounted Panelboards: Same gauge and finish as panelboard front with flanges for attachment to panelboard, wall, and floor.

#### 4.5.1.11 Door Locks

Doors shall have flush-type cylinder locks and catches. All locks in the project shall be keyed alike, and two keys shall be furnished with each lock.

### 4.5.2 Overcurrent Protective

Overcurrent protective devices shall have the frame size, trip rating, number of poles, and auxiliary devices and interrupting capacity rating to meet available fault current as indicated on the drawings or as ordered. Molded-Case circuit breakers shall conform to NEMA AB1, UL 489, FS WC-375 and with minimum rating in accordance with the short circuit and coordination study as per FAA ORDER 6950.2. Circuit breakers shall meet the following requirements:

1) Bolt-on breaker type. Stab-in and plug-in types are not acceptable.

2) Quick make, quick break connections with mechanical trip free switching mechanism.

3) Inverse time, thermal overcurrent trip.

4) Instantaneous magnetic trip.

5) Thermal trip calibrated for 40 degrees Celsius ambient temperature.

6) Electronic trip circuit breakers to have in product line the capability of Long time setting, long time delay, short time delay, short time pick up, short time delay and instantaneous pickup.

7) Capability for electronic trip breakers shall include an arcflash reduction unit product line.

8) Provide breakers with number of poles, voltage rating, current rating, and frame size as indicated on the drawings.

9) Multiple circuit breakers shall have an internal, common trip mechanism; trip-indicating feature; single-pole breakers shall be full size modules.

10) Two and three pole breakers shall be sized in multiples of a single-pole breaker. Branch circuits shall be connected to the individual circuit number, as indicated on the drawings. UL marked as suitable for use with 75 degree Celsius wire; trip-indicating feature; single-pole breakers shall be full size modules.

11) Shunt trip where indicated; 120 V, 60 Hz.

12) Auxiliary Contacts for EPMS System: Provide auxiliary contacts in circuit breakers for EPMS system.

13) Minimum Rating: 10,000 AIC.

14) Circuit Breakers: 200 A and larger; shall have trip units interchangeable within frame size.

#### 4.5.2.1 Multipole Breakers

Provide common trip-type with single operating handle. Breaker design shall be such that overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any three adjacent breaker poles are connected to Phases A, B, and C, respectively.

#### 4.5.2.2 Circuit Breaker With GFCI

UL 943 and NFPA 70. Provide with "push-to-test" button, visible indication of tripped condition, and ability to detect and trip on current imbalance of 6 milliamperes or greater per requirements of UL 943 for Class A GFCI devices, for personnel protection, and 20 milliamperes or greater per requirements of UL 943 for Class B GFCI per equipment protection.

#### 4.5.2.3 Circuit Breakers for HVAC Equipment

Circuit breakers for HVAC equipment having motors (group or individual) shall be marked for use with HACR type and UL listed as HACR type.

#### 4.5.2.4 Arc-Fault Circuit-Interrupters

UL 489, UL 1699 and NFPA 70. Molded case circuit breaker shall be rated as indicated. Two pole arc-fault circuit-interrupters shall be rated 120/240 volts. The provision of two (2) one-pole circuit breakers for shared neutral circuits in lieu of one (1) two-pole circuit breaker is unacceptable. Provide with "push-to-test" button.

### 4.5.3 Accessory Components and Features

Tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

### 4.5.4 Dual Main Panelboards

Dual main panelboards will allow the installation of (2) main circuit breakers rated 100 amp to 225 amp with auxiliary contacts which indicate position and trip status. Main breakers shall coordinate with 20 amp branch circuit breakers up to the 5000 amp of instantaneous fault current. Submittals shall prove this in documentation from the factory. The submitter shall provide FAA written documentation certifying that this panel will coordinate in ALL instances with the provided main breaker up to 5000 amps or greater.

This panelboard will have two Kirk keyed main breakers and operate with a third upstream breaker kirk keyed to allow a closed transition to the alternative source. In a normal configuration, the primary feeder powers the panels. When the upstream primary device is removed from service for scheduled maintenance, the alternate side is energized to feed the loads. This is accomplished by transferring the STS from primary to alternate source and using a Kirk key interlock to close the maintenance bypass breaker in the panel and open the main breaker.

Panelboard shall be equipped with stamped enclosure knockouts. Provide type enclosure suitable for the application. Use NEMA 3R for all outdoor applications.

### 4.5.5 Panelboards with Electrical Power Monitoring System (EPMS) Requirements

1) Panelboards shall have all internal EPMS wiring to devices incorporated into the factory provided wiring. The panels shall be designed to minimize external wiring requirements. This shall be installed in a side car attached directly and prewired into the panel board collection devices.

2) Individual equipment line-ups shall be fully wired and tested by the manufacturer such that the contractor need only provide one connection for communication. The exception to this rule is when specified elsewhere in the drawing set.

3) All connections that leave panelboards and switchboards that leave the gear shall terminate in a terminal board that is clearly labeled and in the wiring diagrams unless otherwise indicated in the drawing set.

4) EPMS Labeling shall comply with EPMS section J.5.

5) EPMS equipment (i.e. power quality meter, sequence of event recorders, etc.) associate with gear provided in this section shall be mounted and installed in separate attached enclosure and be provided to the FAA pre-wired from the factory for field installations.

### 4.5.6 Related Requirements

Section J, Attachment J.5, Electrical Power Monitoring and Control System

## 4.6 TRANSFORMERS

The equipment in this specification are designed and manufactured according to latest revision of the following standards (unless otherwise noted).

- ANSI/IEEE C57.96, Distribution and Power Transformers, Guide for Loading Dry-Type appendix to ANSI C57.12 standards.
- ANSI/IEEE C89.2 - Dry Type Transformers for General Applications.
- ANSI/NFPA 70, National Electrical Code.
- IEEE C57.12.01, General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and / or Resin-Encapsulated Windings.
- IEEE C57.12.91, Test Code for Dry-Type Distribution and Power Transformers.
- NEMA ST 20, Dry Type Transformers for General Applications.
- UL 506, Specialty Transformers.
- NEMA- TP-1-2002.

- NEMA TP-2-2002.
- NEMA TP-3-2002.
- US Department of Energy Candidate Standards Level 3 (CSL-3) Energy Efficiency Standard.

### 4.6.1 General Requirements

Transformers shall comply with NEMA ST 20 for general purpose, dry-type, self-cooled, ventilated transformers. Provide transformers in NEMA 2, drop-proof (optional NEMA 3R with supplied rainshields) shall be constructed of heavy gauge steel enclosure unless otherwise requested. Power transformers shall be 2 winding dry type for general power and lighting applications. Transformers rated 1000 KVA or below shall be UL listed and bear required Listing Mark. Transformer shall have 220 degrees Celsius insulation system for transformers 15 kVA and greater, and shall have 180 degrees Celsius insulation for transformers rated 10 kVA and less, with temperature rise not exceeding 150 degrees Celsius under full-rated load in maximum ambient of 40 degrees Celsius. Transformer of 150 degrees Celsius temperature rise shall be capable of carrying continuously 100 percent of nameplate kVA without exceeding insulation rating. Transformers shall be quiet type with maximum sound level at least 3 decibels less than NEMA standard level for transformer ratings indicated.

Transformer core shall be constructed of high grade, grain-oriented, non-aging silicon steel with high magnetic permeability, low hysteresis, and low eddy current losses. Magnetic flux densities shall be kept well below core saturation point. Laminations shall be miter-cut. Transformer core shall be clamped using insulated bolts through the core laminations to provide consistent pressure throughout the core length. Completed core and coil shall be bolted to enclosure base and isolated from base with rubber vibration-absorbing mounts. Transformer core shall be visibly grounded to enclosure with a copper strap.

Coils shall be copper unless otherwise specified. Transformers shall have following primary voltage no-load tap arrangements unless noted otherwise in plans:

- 15kVA-300 KVA – six (6) 2-1/2 percent taps, 2 above and 4 below nominal voltage.

Enclosures shall meet UL 506 requirements for the following characteristics:

- Ventilation Openings
- Corrosion Resistance
- Cable Bending Space

- Surface Temperature Rise
- Wiring Compartment Temperature Rise
- Terminations.

### 4.6.2 Specified Transformer Efficiency

Transformers, indicated and specified with: 480V primary, 80 degrees C or 115 degrees C temperature rise, kVA ratings of 37.5 to 100 for single phase or 30 to 500 for three phase, shall be energy efficient type. Individually mounted dry-type transformers, 600V maximum, for general power and lighting applications meeting or exceeding the proposed US Department of Energy Candidate Standard Level 3 (CSL-3) energy efficiency standard.

### 4.6.3 Transformers With Non-Linear Loads

Transformer insulation shall be a UL recognized 220 degrees Celsius system. Neither the primary nor the secondary temperature shall exceed 220 degrees Celsius at any point in the coils while carrying their full rating of non-sinusoidal load. Transformers are to be UL listed and labeled for K-13 as indicated, defined as the sum of fundamental and harmonic per UL 1561. Transformers evaluated by the UL K-Factor evaluation shall be listed for 115 degrees Celsius average temperature rise only. Transformers with K-Factor ratings with temperature rise of 150 degrees Celsius rise shall not be acceptable. K-Factor rated transformers shall have an impedance range of 3 percent to 5 percent, and shall have a minimum reactance of 2 percent to prevent excessive neutral current when supplying loads with large amounts of third harmonic current.

### 4.6.4 SUBMITTALS

Manufacturer shall provide copies of following documents for review and evaluation Product data and drawings stating the following:

1) Dimensions including external enclosure and internal core & coil
2) Weight
3) KVA
4) Primary & secondary voltage
5) Percent Impedance.

6) Coil tap arrangement and tap voltage
7) Insulation Class
8) Sound Level
9) Wiring Diagram:
10) Installation Instructions
11) UL rating label drawing
12) Efficiency
13) Inrush current
14) Efficiency Data
15) Core loss or no load loss at 100% voltage
16) Impedance loss or coil loss at rise + 20C Reference
17) Total loss at Rise + 20C reference
18) Efficiency at reference temperature of Rise + 20C: 25% load, 35% load, 50% load, 75% load, 100% load
19) Impedance at reference temperature of Rise + 20C i.e. %R, %X, %Z
20) Regulation at reference temperature of Rise + 20C

### 4.6.5 Seismic-Tested

The manufacturer shall provide seismic-tested equipment as follows: The equipment and major components shall be certified to the seismic requirements of IBC-2006 and IEEE- 693-2006. Guidelines for the installation consistent with these requirements shall be provided by the transformer manufacturer and be based upon testing of representative equipment. The equipment shall be qualified to an equipment importance factor, Ip, level of 1.5.

### 4.6.6 Regulatory Requirements

All transformers shall be:

1) UL listed and UL labeled.

2) Properly labeled in accordance with NEMA-TP-3.

3) Labeled to certify compliance with IBC-2006 and/or IEEE-693-2006.

### 4.6.7 Performance

Transformers shall perform per the following requirements:

1) Dry type general purpose transformers shall be rated as indicated in the drawings.

2) Transformers supplied to this specification shall be able to operate continuously at 100 percent nameplate rating at ambient temperature not exceeding 40 degrees Celsius. Maximum temperature at top of enclosure shall not exceed 50 degree Celsius rise above 40 degree Celsius ambient.

3) Transformer shall have sound levels equal to or lower than that specified below.

    a. Sound Levels (Decibels for 150$^{o}$C), Measured per ANSI C89.2-1986

| KVA | Sound Levels |
|---|---|
| 10 – 50 | 45 |
| 51 – 150 | 50 |
| 151 – 300 | 55 |

4) Transformers shall meet or exceed the energy efficiency requirements of US Department of Energy Candidate Standard Level 3(CSL-3).

5) No load losses (core loss) shall not exceed: 15kVA: 49W, 30kVA: 90W, 45kVA: 100W, 75kVA: 145W, 112.5kVA 205W, 150kVA: 250W, 225kVA: 320W, 300kVA: 350W.

6) Shall meet or exceed DOE 10CFR Part 430 CSL-3 efficiency requirement tested per NEMA TP-2: 15kVA: 97.6%, 30kVA: 98.1%, 45kVA: 98.3%, 75kVA: 98.6%, 112.5kVA: 98.8%, 150kVA: 98.9%, 225kVA: 98.9%, 300kVA: 99.0%.

7) Transformers shall use properly classified UL approved temperature ratings. Provide a UL recognized 220C insulation system capable of continuous operation at 40C ambient without exceeding a 150C temperature rise. Temperature rise ratings shall be in accordance with UL 506. Provide transformers designed for 150C temperature rise unless otherwise noted on drawings.

8) Transformer shall carry the fully rated load continuously when the surrounding air does not exceed 30C/86F average, 40C/140F maximum and adjacent structures do not prohibit the free movement of cooling air.

9) Transformers 15 KVA and above shall be able to meet ANSI/IEEE C57.96 daily overload requirements. Transformers loaded in accordance with this paragraph shall be capable of long service life under thermal conditions specified. There shall be no need for derating

### 4.6.8 Transformer Source Quality Control

Transformer Factory Test submittal shall include routine NEMA ST 20 transformer test results on each transformer and also contain the results of NEMA "design" and "prototype" tests that were made on transformers electrically and mechanically equal to those specified.

### 4.6.9 Accessories

The following transformer accessories shall be available and field installable:

- Wall mounting brackets, for 75kVA and smaller
- Weathershield kits, for all models
- Lug kit

## 4.7 Motor Control Centers

UL 845, NEMA ICS 2, NEMA ICS 3. Wiring shall be Class I, Type B, in NEMA Type 1 enclosure. Provide control centers suitable for operation on 480-volt, 3-phase, 3-wire, 60 Hz system and shall have minimum short-circuit withstand and interrupting rating of 65,000 amperes rms symmetrical. Incoming power feeder shall be cable entering at the top or bottom of enclosure and terminating on terminal lugs. Main protective device shall be molded case circuit breaker rated at amperes rms symmetrical interrupting capacity. Arrange busing so that control center can be expanded from both ends. Interconnecting wires

shall be copper. Terminal blocks shall be plug-in-type so that controllers may be removed without disconnecting individual control wiring.

### 4.7.1 Bus Systems

Provide the following bus systems. Power bus shall be braced to withstand fault current of 65,000 amperes rms symmetrical. Wiring troughs shall be isolated from horizontal and vertical bus bars.

#### 4.7.1.1 Horizontal and Main Buses

Horizontal bus shall have continuous current rating as specified in the design drawings. Main bus shall be copper, silver-plated enclosed in isolated compartment at top of each vertical section. Main bus shall be isolated from wire troughs, starters, and other areas.

#### 4.7.1.2 Vertical Bus

Vertical bus shall have continuous current rating as specified in drawings and shall be copper, tin-plated. Vertical bus shall be enclosed in flame-retardant, polyester glass "sandwich."

#### 4.7.1.3 Ground Bus

Copper ground bus shall be provided full width of motor control center and shall be equipped with necessary lugs.

### 4.7.2 Motor Disconnecting Devices and Controllers

Shall comply with UL 508.

### 4.7.3 Combination Motor Controllers

UL 508 and other requirements in paragraph entitled, "Motor Controllers." Controller shall employ molded case circuit breaker. Circuit breakers for combination controllers shall be thermal magnetic.

## 4.8 Disconnects

### 4.8.1 General-Duty Disconnect Switches

Provide surface-mounted, general-duty type, sheet steel enclosed switches, of types, sizes, and electrical characteristics indicated; rated 240 volts, 200 amperes and below, 60 hertz, with 3-blades, 3-poles;

incorporating spring assisted, quick-make, quick-break switches which are so constructed that switch blades are visible in OFF position with door open. Equip with operating handle which is integral part of enclosure base and whose position is easily recognizable, and is capable of being padlocked in OFF position.

### 4.8.2 Heavy-Duty Safety Switches

Provide surface-mounted, heavy-duty type, sheet steel enclosed safety switches, of types, sizes and electrical characteristics indicated; fusible type, rated 600 volts, 400 amperes and below, 60 hertz, 3-blades, 4-poles, solid neutral; incorporating quick-make, quick-break type switches; so construct that switch blades are visible in OFF position with door open. Equip with operating handle which is integral part of enclosure base and whose position is easily recognizable, and is padlockable in OFF position; construct current carrying parts of high-conductivity copper, with silver-tungsten type switch contacts, and positive pressure type reinforced fuse clips. Provide NEMA type 3R enclosure for outdoor.

### 4.8.3 Fuses

Provide fuses for safety switches, as recommended by switch manufacturer, of classes, types, and ratings needed to fulfill electrical requirements for service indicated. Provide fuses to match equipment label requirements when fuse information is furnished as part of the equipment label.

## 4.9 Identification

Identify field-installed wiring and components and provide warning signs as specified in FAA Standard Design, Section 26 5 53, “Identification for Electrical Systems.” Label each panelboard with engraved laminated plastic or metal nameplates mounted with corrosion-resistant screws, as specified in Section 26 05 53, “Identification for Electrical Systems.” Provide panelboards with nameplates indicating the panel name, system voltage, and phase. Example: Panel EPLA-1051-A: 208Y/120V, 3-phase, 4-wire.

## SECTION J, ATTACHMENT J.5

# 5.0 ELECTRICAL POWER MONITORING AND CONTROL

## 5.1 GENERAL

### 5.1.1 Related Documents

Drawings and general provisions of the Contract apply to this specification.

### 5.1.2 SUMMARY

This specification defines the requirements for both an Electrical Power Monitoring System (EPMS) and an Electrical Power Control System (EPCS). The EPMS system shall be a monitoring system only and shall not control any equipment. The EPCS system shall meet all of the requirements of the EPMS software with the addition of being able to control breakers and equipment. If required the system shall be both a monitoring and control system and be referred to as Electrical Power Monitoring and Control System (EPMCS). The software platform shall be a SCADA system capable of both monitoring and control.

All written material, including electronic documents, shall not be copyrighted or require the FAA to obtain special permission for reproduction for any purpose. This shall include, but not be limited to, Operations and Maintenance Manuals, Training Material, Shop Drawings, As-builts, Software Code, Software Code Documentation, and Hardware/Software Configuration Documentation. The FAA shall have the right to reproduce this information, as well as incorporate it into their internal training programs and documents.

Refer to the following related sections or manufacturer's cut-sheets as well as the drawings for details on quantities of monitoring points and work to be performed.

1) Automatic Transfer Switches.
2) Paralleling Switchboards.
3) Switchgear and Switchboards.
4) Distribution Equipment.
5) STS.
6) General Provisions.
7) PCMS.

### 5.1.3 Standards

All equipment, material, work and testing supplied shall be in accordance with the latest edition and amendments of all applicable standards, codes, laws and regulations listed below:

1) American National Standards Institute (ANSI).
2) National Electrical Code (NEC).
3) Underwriters' Laboratories, Inc. (UL).
4) Institute of Electrical and Electronics Engineers (IEEE).
5) National Electrical Manufacturers' Association (NEMA).
6) Federal, State and local codes and laws.

Seismic Requirements - All equipment furnished shall be in accordance with UBC, Zone 4.

### 5.1.4 Quality Assurance

The manufacturer of the equipment shall have been regularly engaged in the manufacture of the specified remote devices for a period of at least ten (10) years and demonstrate that these products have been utilized in satisfactory use in functioning systems for similar applications. The manufacturer shall have at least ten (10) years demonstrated capability in EPMS/EPCS design, installation, and start-up.

### 5.1.5 Identification

All panels, devices and equipment shall be identified by name or function by means of nameplates. Except as otherwise noted, nameplates shall be of laminated phenolic compound with beveled edges and engraved to display white characters on a black background. Nameplates shall be attached using self-tapping stainless steel screws. Reference General Provision Section J.1.

### 5.1.6 Project Consistency

The vendor shall provide a Project Manager to oversee all EPMS/EPCS related activities, functions, meetings, and deliverables for all FAA projects. This person shall be the main point of contact for EPMS/EPCS related issues between the vendor and the FAA.

Vendor shall strive to design, develop, and deliver a consistent EPMS/EPCS hardware and software product across all FAA projects, per the FAA’s guidance.

### 5.1.7 Training

The vendor shall make training available to the FAA. It shall be geared towards using the application's development utilities and cover methods for modifying and editing SCADA projects. Training provided at the vendor's facility is acceptable.

## 5.2 DRAWING AND DOCUMENTATION SUBMITTALS

(The following shall be submitted in accordance with the General Provision Section J.1)

### 5.2.1 Network Drawings

Detailed EPMS Network drawings showing all point-to-point connections information shall be provided to the Government at the time of or prior to gear approval drawings submittals. These drawings shall be based on the provided A&E final design drawings and show all connections within the EPMS network.

#### 5.2.1.1 Wiring Details

They shall show both field and factory installed EPMS wiring and shall identify the difference between each. All field wiring shall clearly identify all wire types, length constraints, and routing considerations. All field wiring terminations shall have detailed connection information including pin information, wire color, shield termination, gear or device terminal block designations, terminating resistors, and special instructions. Proper shielding techniques and methods shall be used on all cabling to provide reliable signals and minimal data transmission errors and delays. Cable routing recommendations shall be provided as necessary.

#### 5.2.1.2 Communications

Device communication type information such as IP addresses, MODBUS addresses, and any additional setup information should be clearly listed.

#### 5.2.1.3 Points List and Alarming

A detailed list of all monitored points shall be defined in the drawing set. All digital points shall have "Alarm On" point high or low detail listed. FAA defined alarm naming shall be shown on the points list.

#### 5.2.1.4 Drawing Categories

Drawings shall be split up by signal types (communications, timing, sequence of events, points list, etc.)

#### 5.2.1.5 Submittals

Three main drawing submittals shall take place: Approval, Issued for Construction, and As Built. During onsite validation and testing, drawings shall be redlined as necessary. All vendor and FAA redlines shall be incorporated in to the As Built drawing submittal.

### 5.2.2 Rack and Enclosure Drawings

Detailed drawings shall be included for each custom device enclosure, tower switch enclosure, and server rack. These drawings shall include detailed parts lists, elevation drawings with dimensions, interior device mounting details, detailed point-to-point wiring detail, and device designations.

### 5.2.3 PLC Wiring Diagram

This document shall breakdown the relationship between hardware and software for all the PLC drops. The breakdown shall indicate what is physically connected to each terminal of the PLC then associate that connection to a software address and/or variable name.

### 5.2.4 COTS Documentation

The vendor shall supply all available documentation for each piece of equipment in the EPMS/EPCS system. Documentation shall include but not be limited to (if available):

1) User's Guides.
2) Installation Guides.
3) Operation and Maintenance Manuals.
4) Device Wiring Diagrams and Schematics.
5) Electrical Characteristics.
6) Descriptive Literature.
7) Datasheets.
8) Replacement Guides.
9) Troubleshooting Guides.
10) Quick References.

11) Handbooks.

12) Programmers Manuals.

13) Administrative Manual.

Documentation shall be submitted in electronic format upon acceptance of the system.

### 5.2.5 Operations and Maintenance Manual – User Level

The Vendor shall furnish operating and maintenance instructions for the complete arrangement of equipment and devices supplied in the system and for the EPMS/EPCS software application. This manual shall document the FAA specific system architecture and software application. This manual shall provide user level instruction. No administrative content shall be included in the document.

#### 5.2.5.1 Descriptions of Operation and Maintenance

The operation and maintenance manual shall describe in detail the following:

1) The hardware components and their function in the system.

2) The network architecture

3) Types of communications

4) Monitored data

5) User level operation of all included software

6) Connecting with full or web client

7) Alarm list and description

8) Control scheme (EPCS only)

9) Recommended maintenance and schedules

10) Troubleshooting

11) Lowest Replaceable Unit (LRU) List

#### 5.2.5.2 User Level Software Operation

The manual shall provide thorough instructions on how to navigate through the SCADA application. It shall describe how to locate and operate all included user level features. User level operations are defined as all non-administrative operations of the software as defined by the FAA. At a minimum, the following software features shall be covered in detail:

1) Active Onelines
2) Floorplans
3) Alarm and Event Log
4) Third Party Device Screens
5) Metering
6) Legend
7) Trending
8) Reporting
9) Meter Configuration
10) Maintenance Mode
11) Paging

#### 5.2.5.3 Site Specific Content

The manual shall cover all operation of the project/site specific system and software. It is acceptable for a generic manual to be developed for all projects/sites if site specific content and operation can be conveyed by describing components, navigation, and theory of operation used to create the custom content in a generic fashion.

#### 5.2.5.4 Maintenance

Maintenance of the EPMS/EPCS shall be limited to the replacement of the major components as LRU items. Self-diagnostics and troubleshooting algorithms shall be incorporated to minimize the technicians' time to troubleshoot the system. The O&M manual shall include detailed maintenance descriptions and a list of LRU items.

### 5.2.6 Operations and Maintenance Instructions – Administrative Level

The vendor shall provide an operation and maintenance manual that covers all administrative functions of the hardware and software in the EPMS/EPCS system not covered in the user level O&M manual. This manual shall contain the following at a minimum:

1) Network drawing file location and update instructions.
2) Device replacement and configuration instructions.
3) User security administration instructions (add/remove/edit users and access level)
4) Administrative screens and functions
5) Debugging tools
6) Configuration tools (paging, maintenance mode, meter configuration, etc.)
7) Required Windows services list
8) Troubleshooting guide
9) Software application startup/shutdown procedures
10) Communication ports in use
11) LRU configuration
12) Firmware upgrade procedures (reference COTS documents if necessary)

### 5.2.7 Data Backup Plan/Instruction

The vendor shall provide a document defining their recommendation of data backup methodology in detail. It shall include but not be limited to:

1) Filenames and locations of files that contain historical data and are updated on a regular basis (ex: Alarm log files, waveform captures, data log files, database files, diagnostic logs, etc.).
2) Recommended backup frequency
3) Recommendations for external backup

### 5.2.8 Software Upgrade Plan/Instructions

The vendor shall provide documentation pertaining to any software upgrades performed on the system. This documentation shall include step by step instructions for performing the upgrade.

### 5.2.9 Server, Workstation, VDT, and GUI Project Configuration Document

The vendor shall provide a document defining all that is required for a new server, workstation, and VDT to be configured for purposes of consistency in new installation by the vendor or replacement/modification by the FAA. It shall include but not limited to:

1) Separate sections for server configuration, workstation configuration, and Video Display Terminal (VDT) configuration.
2) Loading the operating system and any other required applications.
3) Computer names (per FAA defined template).
4) Site specific user account and password setup (per FAA defined template).
5) Folder/file structure configuration
6) Required drive partitioning.
7) Site specific passwords.
8) Communication configuration.
9) Time sync configuration.
10) Project/file naming.
11) IP address schemes (FAA Defined).
12) Alarm naming (FAA Defined).
13) Point/breaker change of state consistency (aux, trip, etc.).
14) Any SCADA FAA project specific parameters or configurations.
15) Database configuration.
16) Required software and drivers.

17) Network drawing file location and update instructions.

### 5.2.10 Software List

This document shall list all software used throughout the EPMS/EPCS system including versions.

### 5.2.11 EPMS/EPCS Hardware List

This document shall list all hardware used throughout the EPMS/EPCS system including firmware versions and device model numbers.

### 5.2.12 Ethernet IP Address List

This document shall list all EPMS/EPCS device IP addresses by device name.

### 5.2.13 Computer Name, Username, and Password List

This document shall list all computer names, usernames, and passwords for all server, workstation, and VDT computers.

## 5.3 PRODUCTS

### 5.3.1 Manufacturers

Individual components can be from different sources, integrated package and support for the EPMS shall be from the single vendor supplying the switchboard.

### 5.3.2 EQUIPMENT OVERVIEW

The following equipment shall be included and integrated into a complete electrical power monitoring system (EPMS).

1) Work Station

    a. Two VDT 20-inch monitors.

    b. One CPU.

    c. One printer.

    d. Desk with chair.

2) Server Rack

    a. Cabinet.

    b. LAN Switch, 24 or 48 port with redundant power supply (depending on the number of devices in the system).

    c. Server CPU.

    d. Monitor.

    e. GPS with antenna, receiver, and accessories.

    f. Uninterruptable Power Supply (UPS).

    g. Dual input circuit breakers.

    h. Dual power distribution strips.

    i. Pullout keyboard and mouse.

3) Tower Switch Enclosure (If required)

    a. Wall-mount vented enclosure.

    b. DIN-mount Ethernet LAN Switch.

    c. DIN mount mini UPS.

    d. Input Circuit Breaker.

    e. Termination boards.

#### 5.3.2.1 Custom Enclosures

As required, provide stand-alone enclosure(s) to house EPMS devices such as power quality meters, sequence of events recorders, Ethernet gateways, etc. Enclosures shall be wall mountable and include input circuit breaker, terminal blocks, and required power supplies. A mini UPS shall be optional.

### 5.3.3 EPMS/EPCS System Overview

#### 5.3.3.1 Summary

The Electrical Power Monitoring System (EPMS) shall gather, display, and alarm on data from various defined remote devices throughout the power system as defined by the FAA. It shall be a server/client monitoring system. The EPMS is defined to include, but not to be limited to, remote devices for monitoring, protection, device communication interface hardware, intercommunication wiring, monitoring stations, software, software configuration, ancillary equipment, startup, and training services.

#### 5.3.3.2 Turnkey Solution

Once provided with an FAA defined EPMS/EPCS network design the vendor shall provide a complete, ready-to-use system that requires no further configuration or setup once commissioned. The vendor shall be responsible for the complete process from design to installation and testing.

#### 5.3.3.3 EPMS/EPCS Software:

The EPMS software shall be a SCADA based HMI system. The EPMS software shall not be perform any control functions on equipment unless required by FAA system design. The control system would fall under the EPCS category and all requirements listed in this document would apply with the addition of the EPCS control section 5.3.6. All requirements of the control and monitoring system will be defined by the FAA. The software shall have FAA defined GUI screens showing animated powerflow onelines and device diagrams. It shall be capable of capturing, logging, and annunciating on system events and device changes of state.

#### 5.3.3.4 Metering

Strategically placed power quality meters shall be utilized throughout the system to capture anomalies. These meters shall be capable of real-time power monitoring and waveform capture on sag, swell, transient events, etc. Sequence of events recorders shall be utilized to capture high speed changes of state of defined devices with a high degree of accuracy. Circuit breaker trip units with metering and communications capabilities shall be utilized for branch circuit monitoring. Communication to other devices shall be utilized to bring data in to the software.

#### 5.3.3.5 Communication Network Architecture:

The EPMS shall be a stand-alone communications network and GPS timing system. It shall not be connected to any other system (unless determined by the FAA to accommodate paging/emailing capability) and shall be fully capable of operating independent of any other network.

#### 5.3.3.6 GPS Timing System:

The EPMS shall use a GPS timing system to distribute synchronized time to all required monitoring/control devices and computers. This is to ensure accurate time synchronization throughout the monitoring/control system. It shall consist of a GPS antenna and receiver for timing distribution.

#### 5.3.3.7 Battery Backup Power

All necessary and specified EPMS hardware (including but not limited to power meters, computers, tower Ethernet switch, and server rack components) shall have UPS or battery backed power. This shall be in the form of integrated mini UPS devices and/or facility critical power circuits as defined by FAA design drawings.

#### 5.3.3.8 Client Computers:

Client computers shall be used throughout the system to provide access to the user interface. The system shall include one operator workstation desktop computer with printer. In addition the system shall utilize a touch-screen interface with screens as required by the design drawings. These are referred to as Video Display Terminals (VDT). If required, a wireless tablet solution shall be provided.

#### 5.3.3.9 Integrated EPMS Devices:

EPMS devices shall be integrated as much as possible into the switchgear and panelboards as required by the FAA design. These devices shall come fully wired and installed into the gear. They shall be located in compartments such that they are isolated from any exposed bussing. External power circuits shall be provided by the FAA for control power. Gear shall have factory wired terminal blocks for easy field connection of control power circuits. If more than one Ethernet based device exists, they shall be wired to a consolidating switch within each piece of gear such that the installation contractor need only provide one connection for communication to the network. If external wiring is needed due to but not limited to PLC I/O, SER inputs, or time sync wiring all wiring shall be terminated to terminal strips that are easily accessible for field wiring. Testing shall be accomplished by the vendor in the factory to ensure all wiring is installed properly.

#### 5.3.3.10 Open Protocol

The EPMS will utilize open protocol standards such as Ethernet TCP/IP; Modbus over Ethernet TCP/IP; and Serial Modbus RTU.

#### 5.3.3.11 Timing Requirements

##### 5.3.3.11.1 Time Sync

Global Positioning Satellite (GPS) time standard shall be implemented as part of the EPMS for proper sequence of operations and events. GPS timing shall be used for maintaining a 1-millisecond resolution throughout the monitoring system.

GPS timing signal shall be transmitted in the form of both IRIG-B and NTP. All devices capable of receiving/synching to NTP shall be wired and configured for NTP, including but not limited to the server, workstation, VDT's, meters and third party equipment. All devices capable of receiving/synching to IRIG-B shall be wired and configured for IRIG-B, including but not limited to sequence of events recorders, meters, and third party equipment. If a device is capable of synching to both, NTP shall be used. The server, workstation, and VDT's shall all sync to the NTP source.

##### 5.3.3.11.2 Time Stamping

All logged and displayed data on any computer in the system shall show time stamps that are synched to the GPS source and are formatted the same throughout. Time stamping shall occur at the device where the event occurred.

High-Speed Stamping: All points indicated on the FAA defined points list associated with the below listed equipment shall be time and date stamped to 1 millisecond through the use of GPS timing. Necessary EPMS hardware and associated equipment alarm/status contacts shall be provided in order to meet the 1-millisecond requirement as defined by the FAA design drawings. The software will show and log event and alarm times out to 1 millisecond in the sequence in which they occurred.

1) Switchboards/Panelboards - Sequence of event recorders and power quality meter.
2) Any other specified point wired to either a sequence of event recorder or power quality meter digital input.

#### 5.3.3.11.3 PC-Based Timing System

The hardware listed below shall have a PC-based timing system for maintaining a 1-second resolution throughout the monitoring system. The software will show and log event and alarm times out to 1-second in the sequence in which they occurred. Where possible time stamping shall occur at the device where the event occurred. All points indicated on the points list associated with the below listed equipment shall be time and date stamped to 1-second through the use of PC-based timing. Necessary EPMS hardware and associated equipment status/alarm contacts shall be provided in order to meet the 1-second requirement.

1) Switchboards/Panelboards – Circuit breaker trip units and meters without millisecond time sync capability.

2) Generators – Modbus RTU or TCP/IP.

3) UPS Systems - Modbus RTU or TCP/IP.

4) STS - Modbus RTU or TCP/IP.

5) ATS – Modbus RTU or TCP/IP

#### 5.3.3.12 Communication Requirements

The EPMS shall be able to utilize the following standard communications configurations, as a minimum, at the same time:

1) Modbus TCP/IP communications for meters, trip units, Ethernet gateways, third party devices and equipment, sequence of events recorders, etc. shall be utilized if available. CAT-6 Ethernet cable shall be used for cable runs less than 325 feet.

2) All EPMS Modbus TCP/IP device IPs shall be static and adhere to FAA defined IP address scheme.

3) If Modbus TCP/IP is not available for a particular device, Modbus RTU communications shall be used. Direct RS485 communications shall be used for cable runs of less than 3000 feet. Longer RS485 runs can be achieved with the use of a RS485 repeater. RS485 supports communication with up to 32 devices per communication string. Each string shall consist of an approved 22 AWG (or greater) twisted pair shielded cable for RS485 communications.

4) GPS time sync signal distribution shall be in the form of modulated and unmodulated IRIG-B and Network Time (NTP). IRIG-B distribution wiring shall be either shielded coax or twisted pair shielded cable. NTP communicates over standard Ethernet. The GPS receiver shall be the NTP

server. If this feature is not a capability of the receiver, the EPMS server shall be configured as the NTP server and shall sync it's time to the receiver. All Computers and third party devices capable of NTP synching must be configured to sync to the NTP server. If a device requires an additional Ethernet connection for NTP time synching, a second cable shall be run. Time sync signal shall be sensed by all devices connected to the time sync base unit reliably.

5) Ethernet communications of either CAT-6 or fiber optic shall be supported at a 10 BaseT, 100 BaseT, 1000 BaseT, and 1000 Base SX communications speed and shall conform to the 802.3 Ethernet communications standards.

### 5.3.4 EPMS/EPCS Hardware

All EPMS/EPCS hardware components (with exception to the server rack components, workstation components, tower switch enclosure components, and optional custom enclosure components) shall be integrated into the switchgear, switchboards, and panelboards per the FAA design.

#### 5.3.4.1 System Server

System server shall ensure a maximum 1-second refresh rate at workstations and video display terminals (VDT) equipped with industrial PCs. The EPMS/EPCS server shall include 2 factory supplied server computers with at least the following features:

1) Dell PowerEdge R710 rack mounted or approved equivalent.

2) Minimum Xenon 5500 series or newer processors computer with 8GB RAM (if OS does not support 8GB RAM the maximum allowable RAM shall be used), 2.4 Ghz, 3-146 GB 3.5 inch Ultri SCSI hard disk drives configured for on board Raid 5, DVD read/write drive, 17-inch rack mountable flat-panel monitor, video card, dual onboard NIC w/Gigabit ports, remote 101-key enhanced keyboard, mouse, and dual AC power supplies.

3) The operating system shall be Windows Server with a minimum of 10 user license CALs.

4) A minimum of 1 serial port, and 4 USB ports.

5) Server shall come equipped with Adobe Reader and Microsoft Office.

#### 5.3.4.2 EPMS/EPCS Workstation:

The EPMS project shall include 1 workstation with the following features:

1) Dell Optiplex Workstation 790 or approved equivalent.

2) Minimum quad core Intel CPU computer with 4 GB RAM, 2.8 Ghz, 8 MB Cache, two 250 GB hard drives, DVD read/write drive, two 20-inch Ultra Sharp flat-panel monitor, dual video card, full-size 101-key enhanced keyboard, Intellimouse, and external speakers.

3) A minimum of 1 serial port, and 4 USB ports.

4) Windows operating system.

5) Workstation shall come equipped with Microsoft Office Professional, and Adobe Acrobat and Internet Explorer, latest editions.

#### 5.3.4.3 Server Rack

The EPMS/EPCS server rack shall house the following equipment:

1) Cabinet with front and rear access.

2) LAN Switch, 24 or 48 ports with redundant power supply and patch panel (depending on the number of devices in the system).

3) Server CPU on pullout slides.

4) Monitor.

5) GPS with antenna, receiver, and accessories.

6) Uninterruptable Power Supply with aux contacts wired to a nearby I/O device for monitoring UPS and battery status.

7) Dual input circuit breakers. (Clearly labeled with voltage level).

8) Dual power distribution strips.

9) Pullout keyboard and mouse.

10) Fans.

11) Grounding strips.

12) Receptacles (where required).

#### 5.3.4.4 Tower Switch Enclosure (if required)

The EPMS/EPCS tower switch enclosure shall be used when Ethernet runs going up the Air Traffic Control Tower exceed the Ethernet cable maximum distance. The tower Ethernet switch shall house the following equipment:

1) Wall-mount vented enclosure.
2) DIN-mount Ethernet LAN Switch.
3) DIN mount mini UPS with aux contacts wired a nearby I/O device for UPS and battery monitoring.
4) Input circuit breaker for incoming power feed.
5) Termination boards.

#### 5.3.4.5 Fast Ethernet Switches

The EPMS/EPCS project shall include Fast Ethernet Switches with the following features:

1) Dell Power Connect 3524 rack mount or approved equivalent. These are 48/24 network ports for 10, 100, 1000 Base-T, 2 SFP transceiver slots, and 1 management port.
2) Full duplex, auto sensing, flow control, layer 2 switching.
3) Status indicators with link activity, speed, collision status, duplex mode, power, redundant power.
4) Redundant power supply.

#### 5.3.4.6 Printers

Provide 1 color inkjet or color laser network printer.

#### 5.3.4.7 Touch-Screen Monitors, VDTs

The EPMS/EPCS project shall include touch-screen monitors with industrial PCs meeting the minimum requirements (quantities determined for each project):

1) 20-inch analog resistive or capacitive touch-screen.
2) 1280 by 1024 resolution 256 colors (minimum). Resolution shall support the software requirements.

3) Intel CPU based.

4) Microsoft Windows operating system.

5) 120GB hard drive.

6) 10/100 Ethernet connection.

7) 24, 48 or 125 VDC, 120 VAC.

#### 5.3.4.8 Wireless Mobile Tablet

The EPMS graphics screens shall be capable of being viewed on a wireless mobile tablet. The tablet shall have a touch interface for navigating screens and a battery life with a minimum of 2 hours. Additional tablet specifications shall be determined by the vendor. If custom screens are required for proper viewing on the tablet, these shall be developed and tested as well. The necessary wireless network will be provided by the FAA.

#### 5.3.4.9 Distributed Processing Modbus Masters and Protocol Converters

The EPMS/EPCS project shall include the required Distributed Processing Modbus Masters and Proprietary Protocol Converters as indicated on the drawings.

#### 5.3.4.10 Power Quality Meter

##### 5.3.4.10.1 Basic Measurements

Basic measurements shall include:

1) Revenue Grade metering that meets or exceeds ANSI C12.20 Class 0.2 and IEC687 (Accuracy)

2) Instantaneous 3-phase voltage, current, frequency, and power factor

3) Energy: bi-directional, absolute, net, time-of-use, loss compensation

4) Energy Demand: rolling block, predicted, and thermal

5) Harmonics: individual harmonic distortion up to the 63$^{rd}$ or better

6) Transient detection: 17us at 60Hz, and sag/swell recording or better

#### 5.3.4.10.2 Basic Inputs

Basic inputs shall include:

1) Five voltage inputs capable of measuring three phases, neutral, and ground for 480/277V and 208/120V systems.

2) Four current inputs capable of measuring three phases, and neutral.

#### 5.3.4.10.3 Basic Compliance Monitoring

Basic compliance monitoring shall include:

1) ANSI C37.90.1 (Surge Withstand)

2) ANSI C62.41 (Surge)

3) ANSI/IEEE C37.90.1 – Surge Withstand

4) IEC 1000-4-4 – Fast Transient

5) IEC 1000-4-5 – Surge Immunity

6) IEC 868 – Flicker Meter

7) IEC 61000-4-15 – Flicker Meter

8) EN 50160 FLICKER AND COMPLIANCE MONITORING

#### 5.3.4.10.4 Basic Event Recording

Basic event recording shall include:

1) Disturbance Waveform Capture

2) Steady State Waveform Capture

#### 5.3.4.10.5 Basic Communication Features

Basic communication features shall include:

1) Modbus TCP/IP

2) Synchronization with other Meters via GPS clock or other of equal resolution

#### 5.3.4.10.6 IEEE 1159 Power Quality Monitoring

IEEE 1159 power quality monitoring shall include:

1) Impulsive transient detection to 1 millisecond duration
2) High, medium, and low frequency oscillatory transients
3) Instantaneous sags and swells
4) Momentary sags, swells, and interruptions
5) Temporary sags, swells, and interruptions
6) Long duration interruptions, overvoltages, and undervoltages
7) Voltage Imbalance
8) DC Offset
9) Harmonics (to the 100th order)
10) Interharmonics (0-6 kHz)
11) Notching
12) Broad-band noise
13) Voltage fluctuations (flicker)
14) Power frequency variations

#### 5.3.4.10.7 Advanced Features

Advanced features shall include:

1) Trending and forecasting
2) Memory logging

3) Min/max/average log
4) Alarm/event log
5) Synchronization with other PQMs (GPS clock or cross-triggering)
6) Adaptive waveform capture
7) Disturbance waveform capture
8) Steady-state waveform capture
9) Waveshape alarm
10) Disturbance alarm
11) Digital input/output capability with alarming
12) Setpoint-driven alarms (voltage, real and apparent power, current, power factor)
13) IEC, ANSI accuracy compliance

#### 5.3.4.11 Sequence of Events Recorder

Sequence of Event Recorders meeting the following requirements (Note any exceptions taken with a detailed description):

1) I/O: Distributed I/O modules.
2) Event Time Stamping: Events shall be recorded to the 1 millisecond accuracy and shall be logged in the sequence in which they occurred.
3) Logging: Logging shall take place onboard. SCADA software application shall access the onboard log to retrieve events. Device shall retain events onboard when device power is lost.
4) Communications: Modbus TCP/IP with a 10 Base-T Ethernet connection.
5) Time Sync: The module shall be capable of receiving an IRIG-B time code signal or NTP time syncing signal with NTP being the preferred method.
6) Debounce: The module shall contain circuitry or software filter to ensure that “chatter” or “bounce” encountered during contact change does not initiate erroneous alarms.

7) Power: 24, 48 or 125 VDC, 120 VAC.

8) On-board Event Memory: 5000 events minimum.

9) Configuration: Shall be configurable via web interface along with a serial connection over RS-232.

10) Operating Conditions: Operating Temperature: -20 C to +85 C, Humidity: 0 to 95% non-condensing.

11) Standards: Device must meet all international standards for Electromagnetic Emissions

12) FCC Part 15 Subpart B, Class A Class A Digital Device, Radiated Emissions EN55011 (CISPR 11) Radiated/Conducted Emissions (Group 1, Class A)EN55022 (CISPR 22) Radiated/Conducted Emissions (Class A)EN50081-2 Electromagnetic Compatibility, emissions.

#### 5.3.4.12 Ethernet Gateway

Ethernet gateways shall meet the following requirements:

1) Communications: Ethernet gateway shall provide means to convert a 10/100BaseT Modbus TCP/IP to a Modbus RTU over RS-485.

2) Configuration: The gateway shall be configurable via web interface along with a serial connection over RS-232.

3) Power: 24 Vdc or 120 Vac.

#### 5.3.4.13 GPS Time Sync System

GPS system shall be comprised of receivers, cables, antennas and associated mounting hardware and shall be provided and configured for interfacing to the EPMS hardware. GPS hardware is to be provided by the EPMS supplier. GPS receiver shall be mounted in the server rack. Antenna shall be field mounted by installation contractor.

Receiver shall provide at a minimum modulated and unmodulated IRIG-B outputs, NTP output, and serial port output options.

Vendor shall supply in-line antenna cable surge suppressor. This shall be field installed by installation contractor.

### 5.3.4.14 Mini UPS

Mini-UPS shall have the following characteristics:

1) Battery Packed Power: All necessary and specified EPMS hardware (including but not limited to power meters, computers, tower Ethernet switch, and server rack components) shall have UPS or battery backed power for a minimum of 15 minutes on total loss of commercial power. Server rack equipment (server, Ethernet switch, and GPS receiver) shall have UPS or battery backed power for a minimum of 30 minutes on total loss of commercial power. This shall be in the form of integrated mini UPS devices and/or facility critical power circuits as defined by FAA design drawings.

2) Monitoring: UPS must have monitoring capabilities including but not limited to “Load Not Supported by UPS" and "Battery Fault". These should be wired to a terminal block.

3) Maintenance: All mini UPS’s shall have the capability to perform a self-test to verify proper UPS operation.

### 5.3.4.15 Programmable Logic Controls (PLCs)

EPCS PLCs shall meet the following minimum requirements:

1) Power Supply Module: All PLC drops shall be capable of acceptting the DC voltages 5V, 24V, 48V, and 125V and AC voltages 24V and 120V as the supply power of the entire drop.

2) Input modules:

    a. All PLC drops shall be capable of accept the DC voltages 5V, 24V, 48V, and 125V and AC voltages 24V and 120V as Discrete Digital inputs.

    b. The system shall contain circuitry to ensure that “chatter” or “bounce” encountered during contact change does not initiate an erroneous signal.

3) Output modules:

    a. All output PLCs shall activate by either applied voltage or dry-contact closure.

    b. Dry-contact closure shall be either solid state (ex. triac) or relay contacts.

    c. Relay contact type outputs shall be voltage free, isolated from ground, and fully independent from each other, with a minimum contact rating of 2 amps.

d. Output PLC using applied voltage as its output shall have modules capable of producing DC voltages 5V, 24V, 48V, or 125V or AC voltage 24V, 48V, or 125V.

4) Warranty: Servers, workstations, and switches shall have a 3-year warranty from the manufacturer, with on-site response time not to exceed 4 hours. Printers, VDT's, and tablets shall carry standard manufacturer's warranty.

### 5.3.5 EPMS/EPCS SOFTWARE REQUIREMENTS

#### 5.3.5.1 Overview

The EPMS/EPCS SCADA software platform shall be commercial off-the-shelf (COTS), requiring no custom code development. The EPMS/EPCS server software shall be designed on a Microsoft Windows-based platform and have on-line full-screen editing to facilitate the programming and monitoring of the system. The EPMS/EPCS server, full client, and web-based client locations will allow the monitoring of vital system parameters and provide a scalable system for future expansions without replacement of the EPMS/EPCS hardware or software. The proposed SCADA software platform shall support unlimited web-based clients and unlimited monitoring points for server and clients.

The SCADA software application shall communicate with all monitored devices to gather data for purposes of displaying, trending, logging, and alarming data. The application shall also be capable of remotely controlling breakers and devices in the system if required by the FAA (see Section 5.3.6).

#### 5.3.5.2 Configuration

All attempts shall be made to maintain a standard configuration across FAA SCADA projects. Software configuration standardization shall also be maintained for the following:

1) Point/breaker change of state consistency (aux, trip, etc.).

2) Project/file naming.

3) Site specific user account, access levels, and password setup (per FAA definition).

4) Database configuration.

5) Alarm nomenclature, behavior, and priority (per FAA definition).

6) Project specific parameters.

7) GUI oneline device symbols, colors, fonts, animation, behavior, navigation, third party device screens, etc.

#### 5.3.5.3 Server and Clients

Server shall not be used on a frequent basis, only for configuration purposes by an administrator. Servers shall be configured so that it only can be accessed by an admin. Users can only access server through a client from EPMS workstations. Server shall have auto-reboot capability enabled so that upon return from a power failure, the server automatically reboots, logs in, and all necessary programs automatically launch without user intervention. The server shall lock itself out immediately.

The workstation shall have auto-reboot capability enabled so that upon return from a power failure, the workstation automatically reboots and the client shall then automatically launches without user intervention.

All attempts shall be made to maintain a standard server, workstation, and VDT configuration across FAA projects. The FAA will provide a template to achieve consistency in the following areas:

1) Computer names (per FAA defined template).

2) Site specific user account, groups, and password setup (per FAA definition).

3) IP address schemes (per FAA definition).

Configuration standardization shall also be maintained for the following:

1) Folder/file structure configuration.

2) Required drive partitioning.

3) Communication configuration.

4) Time sync configuration.

##### 5.3.5.3.1 Distributed Processing and Redundancy

SCADA software processing shall be capable of being distributed across multiple processors and/or servers for higher redundancy and performance. Software shall be configured to distribute processes across multiple processors as a standard configuration. If required by the FAA design, dual servers with

redundant processes on both servers shall be utilized. A copy of the software shall run on the second server in a hot standby configuration.

#### 5.3.5.3.2 Clients

The EPMS software shall have the main application running on the server machine and be configured for both web-based clients and full clients (if available). At a minimum, dedicated EPMS workstations and VDT's shall be configured as web-based clients, but full clients are preferred if available. If tokens are required, they shall be soft key tokens, as opposed to physical tokens. The web-based clients shall require no loading of software to view all the EPMS screens, data, meter configuration, and waveforms. Any computer that is connected to the EPMS network and has a properly configured IP address and compatible browser should be able to connect as a web-based client. The web-client at a minimum must be fully compatible with Microsoft Internet Explorer version 8 or higher.

### 5.3.5.4 Monitored Data

The SCADA software shall communicate to all monitoring devices in order to gather data for purposes of displaying, trending, logging, and alarming data. These devices include breaker trip units, protective relays, third party equipment, and any digital meters on the electrical distribution system. Additional analog and discrete statuses required to be monitored as required by the FAA system design shall be tied back to I/O units and communicated back to the power monitoring software.

The EPMS software shall be able to take incoming monitored data and perform mathematical and logical operations for control, viewing, logging or alarming.

### 5.3.5.5 Graphics and Display

The EPMS SCADA software shall include a graphical package that allows specific configurable custom graphic screens to match customer oneline drawings and floor plans to match facility design drawings as agreed upon by the FAA. They shall accurately and clearly depict real-time power flow throughout the monitored portion of the system. FAA shall define colors, naming/numbering schemes, and general arrangement of screens. The software shall be capable of supporting any number of screens and the FAA shall not be limited in the number of screens requested. Screens shall have a consistent look and navigational structure. This custom interface will be referred to as the SCADA application.

### 5.3.5.6 Screens

The EPMS software shall provide the following screens as standard in the software:

1) Active Onelines.
2) Alarm Log.
3) Event Log.
4) Floor Plans.
5) Third Party Devices.
6) Legend.
7) Network Drawings.

#### 5.3.5.6.1 Template

Throughout the user interface the screens shall have a consistent template that contains the following information listed below. Exceptions may be made as necessary if approved by the FAA.

1) Minimum of last three unacknowledged alarms sorted by active then inactive.
2) A compact navigational scheme that is intuitive and user-friendly for both touch screen and mouse interfaces. One or two click access shall be provided to the following at a minimum:
    a. Onelines
    b. Floorplans
    c. Alarm logs
    d. User Login
    e. Legend
3) Small FAA defined logo.
4) Site name.
5) Time and date.
6) Currently logged in user.

#### 5.3.5.7 Navigation

The SCADA application shall incorporate an intuitive and user-friendly navigational control scheme that allows the user to navigate between screens. The navigational controls shall be designed for use with both pointer (mouse) and touch screen interfaces. They shall have a consistent look throughout the application so that the function of each control is clear before it is activated by the user.

#### 5.3.5.8 Active Oneline

The Active Oneline shall be a representation of the power system's oneline drawing that is animated and colored based on logical combinations of monitored data throughout the system.

##### 5.3.5.8.1 Components

1) Equipment and Gear – Representation of switchgear, switchboards, panelboards, and third party devices typically containing buses, breakers, meters, and other symbols enclosed in an identifying border and clearly labeled

2) Symbols – Representation of breakers, switches, fuses, meters, third party equipment, transformers, or other various devices throughout the power system

3) Power Flow Lines – Representation of power conductor paths between pieces of gear and equipment

4) Buses – Representation of busing inside of a piece of gear or equipment

##### 5.3.5.8.2 Animation

1) Power Flow Lines and Buses

    a. Power flow lines and buses shall be colored based upon whether or not they are in one of three states: Red for Energized, Green for De-Energized and Magenta for Unknown

    b. Any line or bus that is not monitored, cannot be calculated, or cannot be logically determined shall be colored Black

    c. Lines crossing between screens shall be shown on both screens and animated identically. Navigation shall be provided to follow the continuation of the lines between screens. Labels shall also be provided stating the destination gear/device at the beginning/ending points of the lines

d. Power flow lines and buses are animated based on metered values and/or the logical combination of metered values and breaker states

2) Symbols

a. If possible, symbols shall be colored and animated based on the state of the monitored device as defined by the FAA

b. Breakers and switches are animated with a standard breaker symbol depicting open/closed/tripped/withdrawn state

c. UPS, Static Transfer Switches, Automatic Transfer Switches, and Generators shall be colored and animated according to their internal operation as defined by the FAA. Third party device states shall be provided in dynamic text form near the respective symbols

d. Transformers shall be colored to match connected power flow lines

e. All other symbols' animation shall be defined by the FAA as required

f. Any symbol or bus within a symbol whose state cannot be determined due to communications loss or other reasons shall be animated in such a way as to clearly identify it is in an unknown state

g. Any symbol or bus within a symbol that is not monitored, cannot be calculated, or cannot be logically determined shall be colored Black

h. Symbols shall be standard electrical symbols

3) Power Flow Methodology

a. All power flow lines and buses shall be animated based on either voltage read from a meter, under voltage relay, or other voltage sensing devices directly monitoring them whenever available. Lines directly tied to a third party device input or output shall be animated based on metered values available from the device

b. No lines or buses shall be animated based a device whose communication rate does not allow the animation refresh rate to meet the minimum requirements for real-time monitoring as specified in section 5.3.5.16 Refresh Rate.

c. Lines and buses not directly metered shall be animated using logical combinations of metered buses and breaker states. Logic shall be continued through the oneline until a metered bus or device is reached

d. Where possible, animated lines and buses shall derive their state not only from devices upstream but devices downstream as well

e. An animated line or bus' state that cannot be determined due to device communication failures or conflicting logical states shall display a third animated state and have the color Magenta. In the case where multiple voltage sources can animate a line or bus and the sources conflict (energized, de-energized, or unknown) the following precedence shall be followed:

f. If at least one source is energized animate as energized.

g. If no source is energized and at least one is unknown animate as unknown.

4) Scripting

a. Active oneline screens shall have the capability to have animation driven based on custom written code where necessary to properly animate the state of a line, bus, breaker, device status, alarm message, or other visual indication.

### 5.3.5.9 Detailed Oneline Screens

The SCADA application shall have a detailed representation of the power system oneline including power flow, gear buses and interconnection, breakers, third party devices and statuses, meter locations/values, etc. as defined by the FAA. This shall be based on the FAA defined oneline and shall include all equipment within the power system.

Oneline screens shall contain as many devices as possible while still maintaining a neat, uniform, and readable appearance. As necessary, multiple screens shall be used to divide the power system in to manageable sections. The FAA shall be involved in the screen division process. Screens shall be linked together for ease of navigation.

Power flow lines shall be shown between all monitored pieces of equipment. Gear and third party devices shall have borders around them and shall be clearly labeled. They shall link to the respective floor plan

drawings. Third party devices shall be clearly labeled and link to their respective detailed screens. Breakers shall be clearly labeled with FAA defined names and breakers with metering shall have links to their respective detailed screens. Identify “Normally Open” breakers with the text “N.O.”. Power meters shall have symbols shown on the onelines and shall link to their respective detailed screens.

The power flow methodology as described in Section 5.3.5.8.2 Power Flow Methodology shall be used to animate detailed onelines. Meters, UVR's, and analog voltage readings shall be used to animate lines/buses if available as defined by the FAA design.

### 5.3.5.10 Overview screen

The SCADA application shall have an overview screen(s) representing the whole power system and animated power flow in a simplified block diagram format as defined by the FAA. It shall show at a minimum animated gear energized states, third party device statuses, and power flow lines between them.

The whole power system shall fit on one screen unless otherwise agreed upon by the FAA. Gear and devices shall be clearly labeled. Each gear and device box shall be linked to their corresponding detailed oneline screen. Third party device status text shall be clearly shown near each device.

Each gear/device shall have a FAA defined abnormal state (any breaker in gear abnormal state – open/closed/tripped, third party device in an abnormal state, etc.). If any abnormal condition exists for a piece of gear or device it shall indicate this clearly.

The power flow methodology as described in 5.3.5.8.2 Power Flow Methodology shall be used to animate overview onelines. Meters, UVR's, and analog voltage readings shall be used to animate lines/buses if available as defined by the FAA design. All common lines and buses shall be animated based on the same monitored points and logical conditions as are used on the detailed oneline screens for consistency. No metered values are required on the overview onelines.

### 5.3.5.11 Metering and Third Party Device Screens

The EPMS shall contain breaker metering, power quality metering, and third party device screens that show all parameters available from the individual remote devices by device, including but not limited to all metered values, load status, alarm status, energy data, harmonic analysis data, device position and/or status, device data logs, configurable settings, waveform capture, sag/swell events, etc. They shall be linked to and accessible from the active onelines with one click access.

#### 5.3.5.11.1 Third Party Devices

All third party devices within the power system shall have dedicated screens for each device. The screens shall be accessible by selecting the device from the active oneline screens. At a minimum, the following information shall be incorporated on the screen:

1) Animated device diagram as applicable - this should mimic the internal operation of the device in all its various states/configurations.

2) FAA defined subset of metered values labeled with applicable units of measure. Common metered values shall be grouped and titled appropriately.

### 5.3.5.12 Floor Plan Screens

Floor plan screen shall have the following characteristics:

1) The application shall include interactive and animated site specific floor plan screens showing gear locations and EPMS hardware device locations.

2) The floor plans shall be divided into sections on different screens as needed so that an appropriate level of detail can be shown.

3) Screens shall have unique FAA defined titles.

4) Room layouts shall be based on FAA provided as built drawings and should be roughly to scale.

5) All gear, third party device, rooms, and EPMS hardware devices shall be clearly labeled.

6) Navigation shall be provided between the active onelines and floor plan screens per piece of gear or third party devices.

7) The floor plan shall animate the gear or third party device border upon the following two actions:

    a. When gear or a third party device is in an alarm condition as defined by the FAA, it shall be highlighted with Red on the floor plan view.

    b. When navigating from the active oneline screen, the selected gear shall be highlighted with Blue on the floor plan screen.

#### 5.3.5.13 Legend

A descriptive detailed legend shall be provided defining symbols, colors, alarm states, and any other clarification for visual indicators needed. The legend shall be hidden but accessible from all applicable screens and may be context sensitive.

#### 5.3.5.14 Network Drawings

As built EPMS network drawings as defined in Section 5.2 – Drawing and Documentation shall be easily accessible from within the SCADA application. It should launch the drawing file in Adobe Reader. The file shall be replaceable with updated drawings if necessary.

#### 5.3.5.15 Readings / Metered Values

A subset of metered values shall be displayed on onelines as defined by the FAA. All other metered values from monitored devices shall be made viewable through device screens. All voltages and currents shall be shown in line-to-line or line-to-neutral format. Units of measure shall be shown for each value.

#### 5.3.5.16 Refresh Rate

Real-time as used throughout the document shall be defined as having a refresh rate of at least once per second. On active oneline and third party screens all real-time data and animations shall update with up-to-date information at least once per second. Within this time period the following shall occur:

1) All points and metered data used for animation shall be read.
2) All logical and mathematical operations used for animation shall be completed.
3) All visible screen elements shall be updated to their current state as determined by their read values and calculations.

Any metered device necessary for proper power flow depiction not meeting specifications for active oneline animation update times due to manufacturer communication limitations must be approved by the FAA.

#### 5.3.5.17 Integrated Waveform Display

Onboard power quality meter waveform captures that are associated with sags, swells, high-speed transients, etc. shall be viewable from within the SCADA application. Waveforms shall be uploaded from the meter to the server and viewable within 5 minutes from when the event occurred. They shall be

displayed in a graphical format showing peak, RMS, and harmonic graphs for both voltages and currents for all phases. It shall have zoom in/zoom out and waveform data point export capabilities.

#### 5.3.5.18 Graphic Quality

Graphic onelines and screens shall be orderly and neat with symmetric, non-crossing lines wherever feasible. All text shall be aligned and uniform.

#### 5.3.5.19 Resolution

Resolution of the graphics must be capable of being displayed on a standard PC display. The workstation, server, and VDT resolution should be chosen based on this.

#### 5.3.5.20 Wireless Mobile Tablet

For wireless mobile tablet (see Hardware Requirements) integration, graphic screens shall be capable of being displayed properly based on tablet resolution. They must be viewable via a web-based client on the tablet and require no loading of software.

#### 5.3.5.21 Animated Charts and Graphs

Animated charts and graphs are acceptable for showing metered values.

#### 5.3.5.22 Graphics Development Software Included

The graphical construction/development utility and any licenses shall be included.

#### 5.3.5.23 Alarming

The SCADA application shall be capable of annunciating alarm conditions within the power system monitored by the SCADA application. These alarms shall be based on acquired and derived values, logical combinations of metered values, and third party device alarms communicated via MODBUS. The FAA will define which values and states represent alarm conditions within the system.

#### 5.3.5.23.1 Alarm States

Each alarm shall have the following states:

1) Active – The alarm condition is currently active
2) Inactive – The alarm condition is not currently active or has returned to a normal state

3) Acknowledged – The alarm has been acknowledged by a user in the SCADA application

4) Disabled – The alarm has been disabled by a user in the SCACA application

Alarms shall become Active when a monitored or derived value changes from its defined normal state to its defined alarm state. Alarms shall also be considered Active if the monitored or derived value is in its defined alarm state upon the SCADA application's start up.

Active alarms that are acknowledged will no longer annunciate, although they still may be displayed prominently. Disabled alarms shall not be annunciated or displayed by the SCADA application if active.

When an alarm becomes Active, it shall be considered Unacknowledged until a SCADA user takes action to Acknowledge the alarm. If the condition clears before a user acknowledges the alarm it shall be considered Inactive Unacknowledged. If the user acknowledges the alarm before the condition clears it shall be considered Active Acknowledged.

#### 5.3.5.23.2 Alarm Priorities

The SCADA application shall be capable of assigning at least four priority levels to alarms. The FAA will assign a priority level to each alarm.

#### 5.3.5.23.3 Annunciation

If at least one Active Unacknowledged alarm condition exists, the SCADA application shall annunciate this condition in the following ways:

1) Playing an FAA provided audio file through any connected workstation or VDT

2) Providing a visual indication within the SCADA application.

3) Sending an e-mail or text message on selected alarms to specified recipients.

4) Active alarms shall be annunciated visually by being displayed on every screen in the SCADA application.

Any text annunciation of an alarm shall contain the following:

1) The date and time the alarm went active accurate to 1 millisecond or to 1 second as applicable

2) The name of the affected gear or equipment

3) An FAA description of the alarm condition

#### 5.3.5.23.4 Response Time

All alarms shall annunciate visually within 2 seconds of the occurrence of the alarm condition.

#### 5.3.5.23.5 Digital Alarms

For each monitored digital point, the FAA will determine which, if any, state represents an alarm condition. Alarms shall be capable of being driven based on the logical combination of multiple digital alarms.

#### 5.3.5.23.6 Analog Alarms

For each monitored analog value, the FAA will determine which conditions indicate an alarm state. These conditions include but are not limited to the following:

1) Pickup threshold and delay

2) Drop out threshold and delay

#### 5.3.5.23.7 Onboard Alarms

Devices with time synch capability and onboard logging capability shall be programmed to annunciate FAA defined onboard alarms. These alarms shall be brought in to the SCADA application for viewing and integration into the alarm logs.

#### 5.3.5.23.8 Third Party Alarms

The SCADA application shall annunciate alarms provided by third party devices via MODBUS. If third party devices have onboard logging capabilities and their internal clocks are synched with the GPS timing system, onboard logs shall be used to annunciate alarm events. If this is not the case, device registers shall be polled. These alarms shall behave similarly to other alarms described in this Section.

#### 5.3.5.23.9 Alarm Delays

The SCADA application shall be capable of providing a delay between the occurrence of an alarm condition and the annunciation of that alarm. A delay shall also be provided between an alarm condition returning to normal and the ceasing of annunciation for that alarm. These delays will be defined by the FAA.

#### 5.3.5.23.10 Time Stamp Accuracy

If millisecond time stamp accuracy is available by a monitoring device alarms from this device shall contain millisecond accuracy within the SCADA application. All alarms not capable of millisecond time stamp accuracy shall have an accuracy of 1 second.

#### 5.3.5.23.11 Alarm Conditions

The SCADA application shall be capable of alarming on the following:

1) Breaker operations (open/close/trip/withdrawn)
2) Power events (sags, swells, high-speed transient events, etc.)
3) Relay contact states
4) Third party device statuses (via Modbus or mechanical contacts)
5) Time Sync Lost
6) Device Communications Lost

All meters, sequence of events recorders and third party devices (if available) shall have an associated GPS time sync lost alarm configured within the SCADA application.

### 5.3.5.24 Logging

The SCADA application shall be capable of logging power system alarms and events as well as events that occur within the SCADA software and displaying them in real time. Logs shall be chronological, easy to view and navigate, and searchable. These logs shall be provided for purposes of real-time power system evaluation, historical event evaluation, and system level analysis.

#### 5.3.5.24.1 Log Modes / Screens

The following logs shall be provided by the SCADA application:

1) Alarm Log
2) Event Log
3) Diagnostic Log

#### 5.3.5.24.2 Searching / Filtering / Sorting

The logs presented inside the SCADA application shall be searchable or filterable by all fields provided in each log entry. The logs may also be sortable by date, time, alarm status and alarm priority at a minimum.

#### 5.3.5.24.3 Log Formatting

The logs shall be displayed in a tabular format with events in rows and event fields in columns. Event field names shall be displayed as column headers. Adequate spacing between columns shall be used so that logs are readable. Font type and size shall be readable. The FAA shall define event/alarm color schemes. The logs shall have an FAA defined color scheme for clearly distinguishing between event/alarm entries.

#### 5.3.5.24.4 Alarm Log

The Alarm Log shall contain all active and unacknowledged power system alarms in their most recent state. Alarms are defined in Section 5.3.5.24.The log shall be sorted using the following hierarchy:

1) First, Acknowledgement (Unacknowledged followed by Acknowledged), ***then***
2) State (Active followed by Inactive), ***then***
3) Date / Time (Most recent alarms followed by least recent)

The Alarm Log shall contain the following fields at a minimum:

1) Date / Time
2) Alarm Description
3) Alarm State (Active, Normal)

4) Alarm Priority

5) Equipment (Device in Alarm) Location

6) SCADA application user (as applicable)

The Alarm Description shall contain the name of the device in alarm followed by the name of the alarm condition as defined by the FAA. In the alarm log, if an active alarm is acknowledged the timestamp of when the alarm went active rather than when the alarm was acknowledged shall be displayed in the alarm entry. When an active alarm is acknowledged, the name of the user who acknowledged the alarm shall be displayed in the alarm log entry. The Alarm Log shall display the following event states FAA defined color schemes:

1) Alarm Active and Unacknowledged

2) Alarm Inactive and Unacknowledged

3) Alarm Active and Acknowledged

Once an alarm is inactive and has been acknowledged, it no longer shall be visible in the alarm log.

#### 5.3.5.24.5 Event Log

The Event log shall contain all power system events recorded by the SCADA application. Power system events shall be defined as the change in state of any alarm or monitored device and any SCADA application user action as defined by the FAA. All alarm changes of state shall be recorded in the Event Log.

The Event Log shall be sorted with the most recent events shown at the top followed by the least recent events. The Event Log shall contain the following fields at a minimum:

1) Date / Time

2) Event description

3) Event state

4) Equipment (Device in Alarm) Location

5) SCADA application user (as applicable)

The Event Description shall contain the name of the device in alarm followed by a description of the event as defined by the FAA. In the Event Log an alarm going active, returning to normal, being acknowledged, or being disabled shall be recorded as separate events and therefore each shall retain its respective timestamp.

The Event Log shall display the following event states using the FAA defined color scheme. The scheme shall correspond with the Alarm Log scheme as shown.

1) Event Active (use Alarm Active Unacknowledged color)
2) Event Inactive (use Alarm Inactive Unacknowledged color)
3) Event Acknowledged (no corresponding Alarm color)
4) Event Disabled (no corresponding Alarm color)
5) Event Occurrence (use Event Inactive color)

The Event Occurrence state shall be used for events that do not correspond to system alarms and do not have on/off states. An example of such an event is a user login. The Event Log shall record events including but not limited to the following:

1) State changes for all FAA defined alarms (active, inactive, acknowledged, disabled)
2) Breaker operations (open, close, trip)
3) Power events (sags, swells, high-speed transient events, etc.)
4) Communication loss/restoration with any monitored device in the EPMS/EPCS
5) Time sync lost by any monitored time synched device
6) PLC initiated sequence
7) User logins/logouts
8) Log entries from third party devices if available via MODBUS as defined by the FAA

The Event Log shall hold a minimum of 20,000 entries for historical viewing.

#### 5.3.5.24.6 Diagnostic Log

The Diagnostic Log shall record events useful to a SCADA application administrator for troubleshooting SCADA software related issues. The log shall be sorted from most recent to least recent events and show the date, time and description of each event. The following types of events shall be recorded in the diagnostic log:

1) Communications device failures / degraded status

2) SCADA application internal errors

#### 5.3.5.24.7 Time Stamp Resolution

Time entries in all logs shall be displayed in a format consistent with the rest of the SCADA application (24hr UTC) and have millisecond resolution. If millisecond accuracy is not available for a particular event, it shall display the milliseconds as “000” or otherwise indicate that millisecond accuracy is not available.

#### 5.3.5.24.8 Acknowledging Alarms

A SCADA application user with the required privileges shall be able to acknowledge active or inactive alarms from the Alarm Log screen. The acknowledgement of an alarm shall be a system event that is recorded in the event log along with the name of the user that acknowledged the alarm.

The SCADA application shall provide functionality for a user to acknowledge multiple or all unacknowledged alarms at once.

#### 5.3.5.24.9 Disabling Events and Alarms

A SCADA application user with the required privileges shall be able to disable alarms or events from either the Alarm or Event log screen. A screen containing all possible alarms and events shall also be provided for the purpose of disabling all desired alarms.

A disabled alarm or event shall not be recorded or displayed in any log. The action of disabling an alarm shall be defined as a system event and therefore shall be recorded in the event log along with the name of the user that performed the action.

The SCADA application shall provide a screen showing all currently disabled alarm and events for the purpose of easily enabling these items. A user shall be able to re-enable alarms or events.

#### 5.3.5.24.10 Commenting on Log Entries

A SCADA user with the required privileges shall be able to add a short descriptive comment to each entry in any log. Comments shall be stored and be viewable from within the application and in logs that have been exported.

#### 5.3.5.24.11 Log Exporting

The SCADA application shall be capable of exporting all or a part of any stored log. The log shall be exported in a tabular format with log entries as rows and fields as columns. All fields available for each entry shall be exported. The export file shall be viewable in Microsoft Excel.

#### 5.3.5.24.12 Archiving

All logs except the Alarm Log shall have archive capabilities such that all data recorded in a log is retained in the SCADA application, an archive, or both. Archived log entries shall be easily accessible and viewable using software provided with the EPMS server.

### 5.3.5.25 Data Trending

The SCADA application shall have the capability of trending all monitored and derived values. Trending shall be user initiated and fully integrated into the application. The application shall display trended values in a user configurable interactive graphical format.

#### 5.3.5.25.1 User Initiated Trending

A SCADA user with the appropriate privileges shall be able to initiate trending on any real or derived data point within the system from within the SCADA application. The time interval of the trend shall be user selectable in discrete time blocks from 1 second to several hours. The trend shall have a user defined or an unlimited duration.

#### 5.3.5.25.2 Constant Trending

If available, the trending system shall maintain data recorded at regular intervals for all real or derived data points and alarms. This data shall be retained for at least six months and shall be made available for trending when later analysis is required.

#### 5.3.5.25.3 Trend Display

Trended data shall be displayed in a graph format with time on the x-axis and selected data values on the y-axis. The scale of both the x and y-axes shall be user selectable. The application shall be capable of displaying at least four trended values on the graph simultaneously. The user shall be capable of selecting distinct colors for each value from a palette of at least eight colors.

#### 5.3.5.25.4 Real-Time Mode

The trending system shall have a real-time mode to allow all trended values to update graphically as new data is acquired.

### 5.3.5.26 Reporting

The reporting package shall be integrated into the EPMS software application. It shall be accessible from any client computer, allow configuration of custom reports, and allow generating, viewing, saving, and printing of all reports. The reporting package shall meet the following criteria at a minimum:

1) Software shall be provided with commands to generate and format both tabular and graphical reports (including bar charts, pie charts and curve plots) for displaying, printing, and storing on hard disk.

2) Reports shall be stored by type, date, and time. The destination of each report shall be selectable by the user.

3) Reports shall use database dynamic values and parameters, values calculated using the database, and reports stored on disk.

4) Parameters used in reports shall be user-defined.

5) Reports shall be processed to avoid interference with normal workstation computer tasks.

6) The report shall contain the time and date when the sample was taken, and the time and date when the report was printed.

7) Reports shall be user-definable to show information in the system database.

8) The system shall include software to produce reports on the current status of any equipment or parameters in the data base.

9) The software shall provide for generating profile reports by sampling and storing defined parameters on a user-defined and selectable time interval basis.

10) The reporting package shall allow for scheduling of and subscription to reports.

#### 5.3.5.26.1 Standard Reports

The following standard reports shall be included as a minimum:

1) Energy and Demand Reports: Energy and demand for individual gear monitored by power meters in the system. Energy and demand should have the capability to support the local utility rate structure. The Energy and Demand report shall include, at a minimum, aggregation of loads from a number of power monitoring devices accomplished by grouping the devices within a report. The reports shall be able to display total consumption, cost, and peak demand of the energy used for a group, sub-group or device, based on any date range.

2) Power Quality Summary: The power quality summary shall be able to be organized in logical groupings of equipment as determined by the FAA. Power Quality reports shall include CBEMA reports, voltage transient reports, interruptions, and steady state reports for all devices supporting these functions.

3) Load Profile Analysis: Load profile analysis to show facility power usage over a defined period of time.

### 5.3.5.27 Meter Configuration

A utility shall be provided to allow all adjustable power quality meter parameters such as thresholds, delays, enable/disable, associated waveform captures, etc. to be configured for onboard alarms including but not limited to sag/swell, overvoltage/current, undervoltage/current, high-speed transients, etc. A standalone application is acceptable but shall be made accessible to the user through the SCADA client application and shall not require the user to physically access the server to use this application.

### 5.3.5.28 Paging

The SCADA application shall be capable of notifying FAA specified parties through an email or text message upon any alarm or event in the system. The paging system shall be capable of the following:

1) Paging on any alarm or event in the system.

2) Send a short descriptive message with alarm time, date, and description information as shown in the alarm log. Messages shall be sent when an alarm goes active and when it returns to its normal state.

3) Fully configurable by the FAA after initial setup.

4) Different alarm sets shall be programmable for each separate user/recipient.

5) Configuration of the paging system shall be an administrative function and shall be password protected.

6) Mask particular alarm pages when maintenance mode has been selected for that specific device or piece of gear. See Maintenance Mode section.

7) Scheduling recipients for when they shall and shall not receive pages.

8) Contain a diagnostic log for troubleshooting purposes

9) Send out a health check notification on FAA defined intervals to specified parties to verify proper system functionality.

The FAA shall define recipients, alarms to be paged upon, and schedules. The FAA shall provide an independent secure network connection to allow paging/emailing functionality.

#### 5.3.5.29 Maintenance mode

The SCADA application shall have a maintenance mode feature that meets the following specifications:

1) Allows a user with appropriate permissions to be able to select a piece of equipment or group of equipment from a list and place it in to “Maintenance Mode” which will mask all paging notifications associated with that equipment. Multiple equipment or group selectivity shall be provided.

2) The FAA shall define the pieces of equipment, groups, and any specific alarms that need to be masked.

3) User shall be required to manually remove each piece of equipment or group from maintenance mode upon completion of maintenance.

4) Annunciates an active alarm in the alarm log per piece of equipment or group placed in to maintenance mode that remains active until the equipment or group is taken out of maintenance mode. Once returned to normal, the alarm shall go inactive and be logged in the event log.

5) A visual indication by each piece of equipment or group shall be displayed on the applicable GUI detailed onelines, overview onelines, and floor plans.

6) The maintenance mode interface shall be easily accessible through the SCADA client application.

#### 5.3.5.30 SCADA User Security

The SCADA application shall provide user security that limits the allowed software operations according to user access levels. Users shall be authenticated by username/password credentials.

#### 5.3.5.30.1 Access Levels

The SCADA application shall be capable of supporting at least four user access levels. At least one access level shall require no authentication. The following types of system operations shall be capable of being assigned to distinct user access levels:

1) Viewing power system status (including Active Oneline, metering, and Alarm and Event logs)

2) Acknowledging Alarms

3) Disabling Alarms

4) Setting up Trending

5) Viewing diagnostic information

6) Operating system control features (EPCS only)

7) Device or SCADA Configuration

8) Administrative functions

All system users shall be capable of being assigned to one or more access levels. System operations and users assigned to access levels shall be determined by the FAA.

#### 5.3.5.30.2 User Authentication

Users shall be authenticated using a username and password on a login screen. The SCADA application shall provide access to this login screen from all relevant points in the application. The SCADA application shall be capable of supporting an unlimited number of defined users, each with assigned user access levels. The FAA shall define usernames, passwords, and access levels. It is preferred that windows authentication be used within the SCADA application for user authentication.

#### 5.3.5.30.3 Inactivity Timeout

A user's session shall time out after 15 minutes of inactivity.

#### 5.3.5.30.4 Availability

A user with the appropriate access level(s) shall be able to log in to the SCADA application through any computer, VDT or client attached to the system.

#### 5.3.5.30.5 Logging

The following actions performed by a user shall be logged in the Event log along with the user's username:

1) Login / Logout
2) Acknowledging Alarms
3) Disabling Alarms
4) System control operations (EPCS only)

#### 5.3.5.30.6 Setup

The SCADA application shall be configured with FAA defined users and user access levels prior to commissioning.

### 5.3.5.31 Server and Client Security

At a minimum the server shall be configured with necessary users so that the SCADA application runs on an administrative account. Users must have server administrative rights to log in to the server. FAA shall define all usernames and passwords necessary for accessing servers and clients.

#### 5.3.5.32 Diagnostics

Diagnostics shall be provided to provide information on device or system malfunction, such as devices not communicating, watchdog alarms, stale data indication, etc.

A monitoring and notifications system shall be used to monitor all services and applications necessary for all aspects of the SCADA system to run properly. It shall be capable of notifying FAA specified parties through an email or text message (assuming the FAA provides a secure connection to an email server). It shall also trigger an alarm in the SCADA system. It shall be capable of logging all diagnostic history.

Digital I/O diagnostics page shall be provided showing all I/O devices, defined inputs, and real-time statuses.

#### 5.3.5.33 On-Line Help

At a minimum the Operations and Maintenance Instructions shall be made accessible from the SCADA client application. It shall be viewable in Adobe Reader and be searchable.

The SCADA development environment shall have full on-line, context sensitive, help capability included.

#### 5.3.5.34 Modifications / Upgrades

The SCADA software application shall be capable of future expansion without replacement or upgrade of the hardware or software.

The software must allow for version upgrades without reconfiguration of settings. The FAA shall be capable of upgrading the software to the latest version without user intervention. An automated conversion tool is acceptable. The process must be documented.

### 5.3.6 EPCS System Overview

The Electrical Power Control System (EPCS) shall be a Programmable Logic Controls (PLC) based control system that controls and monitors all the specified breakers and equipment in the distribution system without any further configuration or setup required after commissioning. The EPCS is defined to include, but not limited to, PLCs, voltage monitoring devices, EPCS device communication interface hardware, EPCS device protection, intercommunication wiring, PLC programming workstation, software, and software configuration.

#### 5.3.6.1 System Integration

Individual components can be from multiple manufacturers. Integrated package and support for the EPCS shall be from the single vendor supplying the distribution equipment.

#### 5.3.6.2 Main CPU PLC Cabinet

Main CPU PLCs shall be housed in a separate wall mountable enclosure and include input circuit breaker, terminal blocks, and required power supplies. The enclosure shall have a window for easy viewing of PLCs. Each device/power supply within the enclosure shall be individually fused. Supplied power shall be UPS conditioned power ensuring the PLC will maintain operation during a power outage.

The EPCS shall have two separate CPU PLCs contained within the same enclosure. One and only one CPU shall maintain communications with other PLCs drops throughout the PLC network. All data collected by the primary PLC shall be communicated with the secondary CPU PLC drop in real time to ensure readiness to assume control if the primary PLC fails. If the primary PLC fails the secondary PLC shall take over all PLC control responsibilities.

If a failure occurs on both CPUs the PLC application shall be designed to fail with no change of state throughout the power system.

#### 5.3.6.3 PLC Programming Software

PLC programming software shall have the following characteristics:

1) Platform: The software shall be design for a Windows PC and Server based Operating System.

2) Communication: PLCs shall be programmed using a protocol that is Ethernet TCP/IP based. Proprietary communication hardware shall not be acceptable.

3) Functionality: Software shall use ladder logic to program the PLCs. Ladder logic shall animate providing real time status of currently running code. Data points throughout the ladder logic application shall have the ability to be manually changed or disabled by an administrator.

4) PLC programming software shall reside on the EPMS/EPCS server.

#### 5.3.6.4 Breaker Control

FAA defined motor operated breakers shall have the ability to open/shunt trip(open). PLC breaker status inputs shall be independent of the EPMS. If additional breaker contacts are required for PLC monitoring

above what is available, expansion shall be achieved by the addition of a relay. The EPMS system shall be connected to the breakers internal contacts wherever possible to eliminate additional delay.

The EPCS shall logically prevent any attempt to command a breaker to change to the state that it currently is in or to change to a state that is prevented by a hardwired interlock. If an attempt has been made an event shall be generated in the event log.

The software shall attempt to operate the breaker for at a maximum of 5 seconds. If the breaker does not change state within the defined time constraints the SCADA software shall report a failure to operate alarm. No breaker shall ever attempt to close into a known fault in the power system. Every attempt to operate a breaker shall be logged in the SCADA's event log.

#### 5.3.6.5 Sequence of Operations

A sequence of operations is a sequence that requires the operation of multiple breakers/equipment to complete the command. The following actions shall generate an event the SCADA's event log:

1) Initiation of the sequence
2) Each control operation executed during the sequence
3) Completion of the sequence

### 5.3.7 Licensing and Service Agreement

Software Client Licenses shall support 10 concurrent client users, through a combination of both web and full clients.

For Software Service Agreements, vendor shall include a 3-year software service agreement which provides customer with software upgrades for the software specified above as they are available.

## 5.4 INSTALLATION AND CHECKOUT

### 5.4.1 General

The EPMS/EPCS is an integrated component of the electrical system. The equipment manufacturers shall factory install and wire all CTs (including shorting blocks), voltage taps, circuit breaker trip units, Modbus daisy chain devices, and GPS sync cabling to terminal blocks in a separate compartment for EPMS/EPCS

components within electrical, switchboards, distribution boards, etc. EPMS/EPCS components shall be housed in EPMS cabinets. All interconnecting wiring installation and hookup are the work of the EPMS Contractor.

### 5.4.2 Factory Testing

The following standard factory procedures and tests shall be performed on the equipment provided under this section.

1) Configure and load all software on the EPMS/EPCS server(s) at the manufacturer's factory.

2) Thoroughly test and operate software in a simulated system mode for minimum of 24 hours. Where possible, simulate communications to various system devices to validate oneline and alarm log functionality.

### 5.4.3 Field Startup and Commissioning Service

Upon request the vendor shall furnish both an EPMS/EPCS hardware and software test plan prior to system check out. The FAA shall assist the vendor in onsite testing as required. The FAA shall test the system after the vendor completes system testing, prior to system acceptance. All noted discrepancies will be documented by the FAA and given to the vendor. The FAA shall approve acceptance of the system once the system meets all requirements.

#### 5.4.3.1 Hardware Checkouts

During hardware checkouts the vendor is responsible for:

1) Verifying and troubleshooting the integrity of the point to point wiring.

2) Verifying and troubleshooting the integrity of device communications and resolving any intermittent communication issues.

3) Configuring time sync distribution system and verifying all devices are properly receiving time signal.

4) Coordinating any possible vendor warranty issues.

The vendor shall be responsible for reporting any field wiring issues to the FAA. The FAA shall work with the installation contractor to resolve and retest reported field wiring issues.

#### 5.4.3.2 Software Checkouts

During software checkouts the vendor is responsible verifying the following:

1) All EPMS/EPCS screens properly animate, depict accurate power flow, and show proper device statuses.
2) Alarm and event logs properly populate with all defined alarms.
3) All metered values monitored by the EPMS match the device readings.
4) All custom navigational GUI controls operate properly.
5) Servers and workstations properly reboot upon loss of power and proper applications automatically launch.
6) All devices and computers are properly time synched.
7) Paging system has been properly configured and sends notifications reliably.

## 5.5 FINAL DELIVERABLES

### 5.5.1 General

Prior to official system acceptance, the vendor shall deliver to the FAA:

1) An image of the server hard drives. This image shall be capable of fully replicating the server from the day of commissioning. It shall be delivered on portable USB drive.
2) All documentation listed in Section x.x.x.x – Drawing and Documentation. This shall include As Built network, server rack, and enclosure drawings. They shall be delivered in electronic format.
3) Copies of all software media and original licenses. Include an itemized listing of all software including version number, serial numbers, product keys, etc.
4) A copy of the final EPMS SCADA software project including specific configuration files and databases.
5) All hardware and software test reports.